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An Illustrated Magazine devoted to the Diffusion of Science

Edited by J. McKEEN CATTELL

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THE SCIENTIFIC MONTHLY is the editorial continuation of THE POPULAR SCIENCE MONTHLY, established by D. Appletonand Company in 1872. Under the able editorship of Dr. Youmans it performed for nearly thirty years an important service in presenting the advances of science in a readable form. It led in the advocacy of the doctrine of evolution, publishing as many as a hundred contributions from Herbert Spencer and numerous articles by Darwin, Huxley and other leaders.

During the past twenty-five years under the present editorship the journal has aimed to maintain high standards and at the same time to print articles of interest to the more intelligent part of the general public.

The undertaking is not easy owing to the great development and specialization of science, and to the technical terminology in each field. There is also difficulty because those who have the greatest authority are often unwilling and are sometimes unable to put their results in a form that is interesting and intelligible. It has been said that leading English and French men of science have larger appreciation of the importance of keeping science in touch with literature and life and are more ready to devote their time to this service than is the case in America. It may also be, to judge from the number and circulation of scientific books of general interest, that there is a wider public abroad appreciative of such efforts.

None the less it is the case that neither in France, in England or in Germany is there a journal of the character of THE SCIENTIFIC MONTHLY. It has had the continuous cooperation of scientific men on the editorial side and except for a period in the nineties has earned, even without much assistance from advertisements, sufficient support to defray the cost of publication. But it is obvious that if the support were larger there could be a still better journal.

The corporation of D. Appleton and Company were losing over ten thousand dollars a year on *The Popular Science Monthly* when in 1900 they decided that they were not justified in continuing it. It was worth that much and far more to the public, as the American Museum of Natural History is worth the hundreds of thousands and Columbia University the millions of dollars a year that they cost. But a private corporation can not subscribe indefinitely a large sum for the public benefit.

The weekly journal *Science* was in like manner supported for a time by Dr. A. Graha Bell and Mr. Gardiner G. Hubbard, at a total expense of about eighty thousand do lars. The are perhaps five hundred journals and proceedings devoted to the publication of re earch wo in America, not one of which pays its expenses on a regular business basis.

It would probably be undesirable for scientific journals to be directly subsidized or e dowed. Indirectly they are now subsidized by the work of contributors and editors support by endowed or tax-supported institutions and by subscriptions from public libraries. In so fa as they require additional support, it can probably best come through an increase in the num ber of public libraries subscribing for such journals and by an increase of subscribers amon those who may realize the importance of supporting an institution essential to society and i betterment.

The present circulation of THE SCIENTIFIC MONTHLY is 8,500. If this number we doubled it would be possible to pay scientific men adequately for their contributions and to im prove the journal in many ways. An effort to increase the circulation should have the suppo of all those engaged in scientific work, for such a journal contributes in large measure to th diffusion of science and to the interest of the general public in scientific progress; it secure new recruits for science and the better support of scientific research and scientific institution The adequate and even generous support of those who appreciate the dominant place of scien in modern civilization and national welfare should also be expected.

For some years no advertisements, except on the cover, have been printed in THE SCIEN TIFIC MONTHLY, for with a circulation under ten thousand they scarcely repay the cos Advertisements are, however, resumed with the present issue. Those printed add to the inte est of the journal, and if the circulation can be increased to 15,000 or 20,000 they would con tribute largely to its support. Readers of the journal can assist by seeing that scientific book instruments, institutions and all opportunities, materials and supplies that are of interest to rea ers of such a journal are advertised there, and by corresponding with those who do advertise.

THE SCIENTIFIC MONTHLY has never before used its reading or advertising pages t ask for increased support. But it seems to be as reasonable to do this as in the case of a librar a museum or a university. The journal has no deficit to meet, the circulation now being large than at any time during the preceding fifty years. But every publication or institution can b made better and more useful than it has been in the past.

No institution should be supported by gifts or by taxation unless it returns to the publ more than it costs. Scientific research, the tea ing of science, scientific publications, apa from other services, have created wealth immeasurably greater than the modest sums that ha been spent on them. The usual way is to give the results to the world and then to beg i money to continue the work. If methods could be devised, such as exist in the fields cover by the patent office and copyright laws, by which scientific work was rewarded in proportio its value to society, the progress of science would be greatly accelerated to the benefit of th whole world.

In the case of a scientific or other journal there must be a certain circulation to meet th costs of manufacture and a circulation that makes it possible to obtain and print advertisement When the circulation exceeds these figures, advance is rapid. The second ten thousand copi can be supplied at half the cost of the first ten thousand and advertisements then contribut to the support. The journal can thus be made better, and so will secure more subscriber and more advertisements, and can be made still better. It is a pleasant thought for publishers in spite of the fact that the process is reversible.

THE SCIENTIFIC MONTHLY has now reached the position where the publishers fee justified in seeking advertisements that will interest its readers, and it is in explanation of th departure that this announcement is inserted on its first regular advertising pages. It is hope that the circulation will continue to increase in geometrical ratio and that there may be pub lished in the United States a journal that will contribute its part to the diffusion and advance ment of science, which it is not unreasonable to maintain is the most important work that ca be done for the nation and for civilization.

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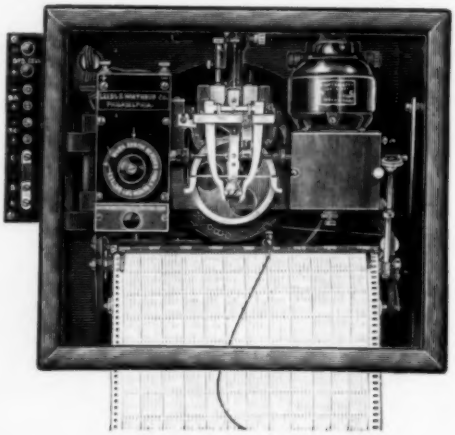

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THE SCIENTIFIC MONTHLY

DECEMBER, 1925

TELEPHONE PICTURE TRANSMISSION

By Dr. HERBERT E. IVES

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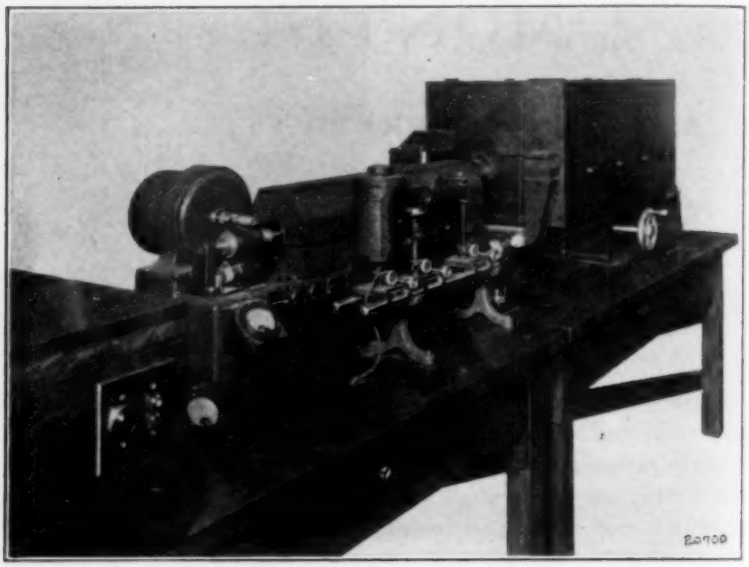
THE picture transmission system which is now in daily commercial operation over the lines of the Bell System is to be distinguished from earlier efforts toward the same end by two features: First, the pictures as received are completely commercial in their character, that is, they are immediately available for all sorts of technical uses, for which they are in fact practically indistinguishable from original photographs. Second, the system is, unlike earlier experimental systems, so worked out that it utilizes without change the existing telephone channels, whether these be wire or radio. The distance to which pictures may be sent is limited only by the distances over which commercial telephone service is available.

The simplest analysis of a picture resolves it into a large number of small patches or elements of varying values of light and shade. A picture transmission system therefore involves first of all some means for analyzing a picture into small elements, or "scanning" it. It involves next some means for communicating a record of the values of these elements to a distant point. It involves finally some means for assuring that the recomposition of the picture elements at the receiving end shall place these in their proper relative positions, that is, some means for synchronizing the sending and receiving apparatus.

The scanning of the picture is accomplished in our apparatus by first preparing the picture to be sent in the form of a transparent film, which may be bent into cylindrical form; this cylinder is then advanced and rotated by a screw motion so that the scanning light spot traverses the entire film in a spiral. A similar

spiral motion is imparted to the sensitive photographic film upon which the picture is received at the far end.

For the purpose of communicating the values of light and shade from one end of the system to the other, we use at the sending end a photoelectric cell. A small spot of light is focussed on the



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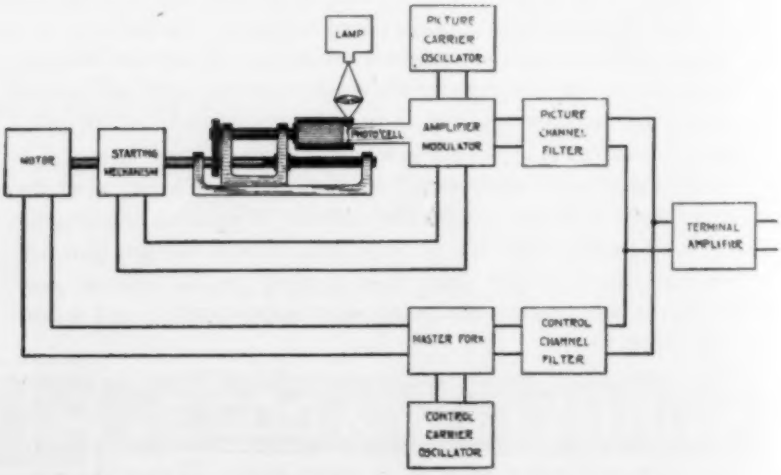

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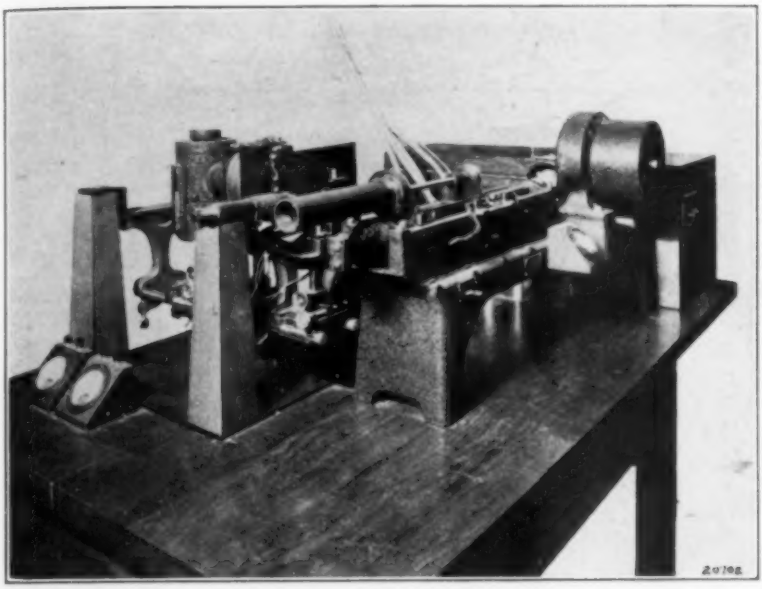

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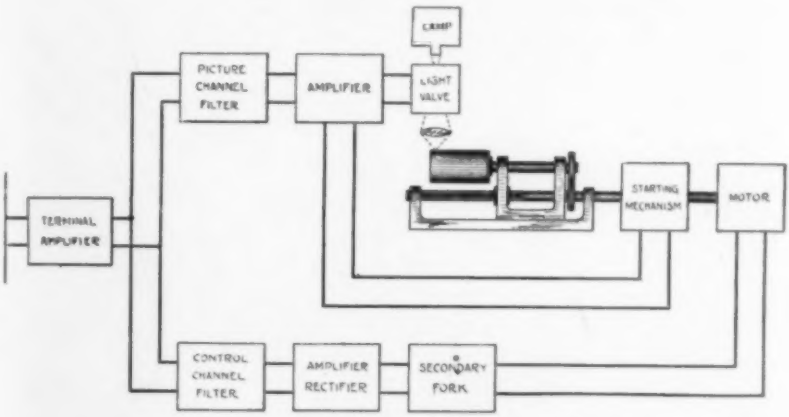
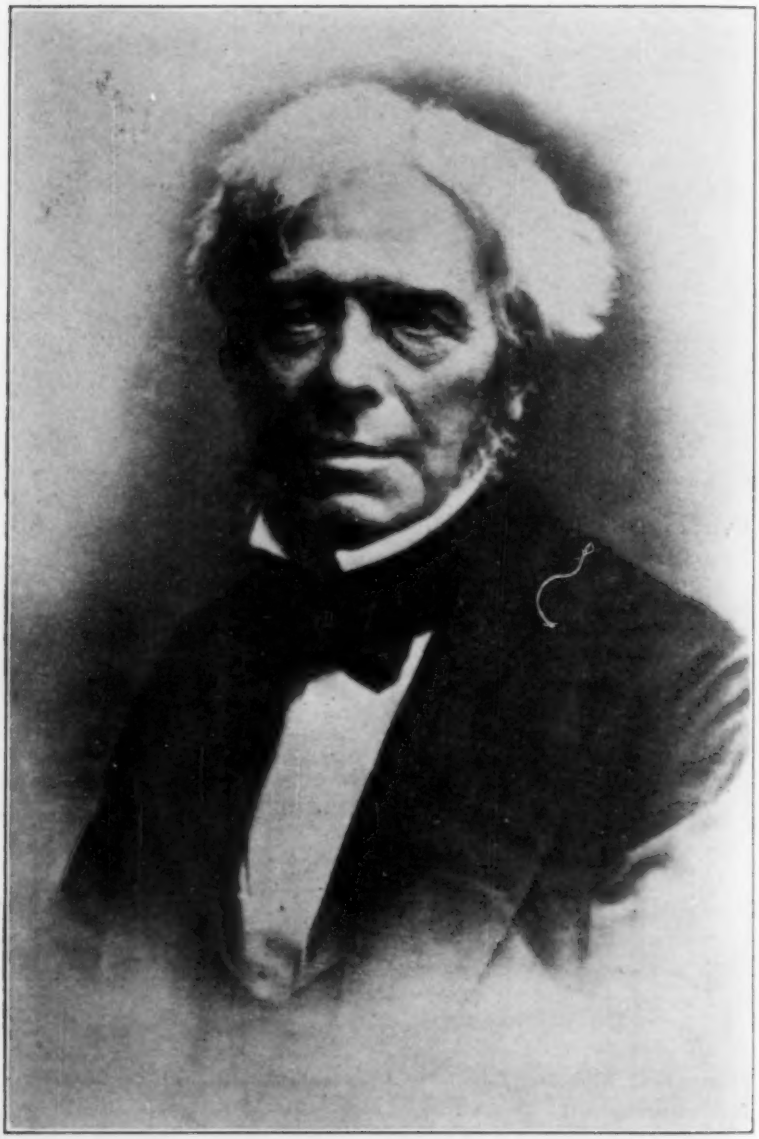


THE RECEIVING APPARATUS IN DIAGRAMMATIC FORM.

transparent film, and, after passing through the films, enters the photoelectric cell. The electric current produced in the cell is directly proportional to the illumination of the cell and follows the variations of light and shade instantaneously. At the receiving end, the electric current which is controlled by the action of the photoelectric cell passes through a narrow ribbon which stands in a magnetic field and by its resultant lateral movement acts as a



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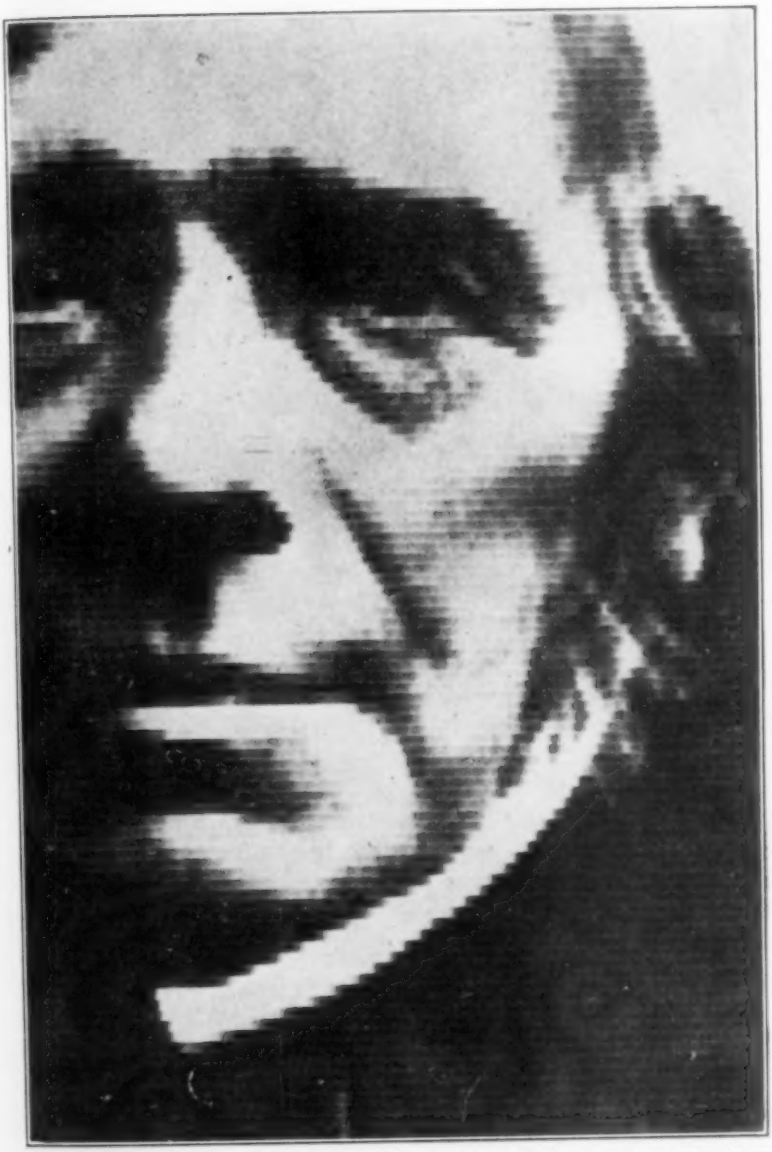

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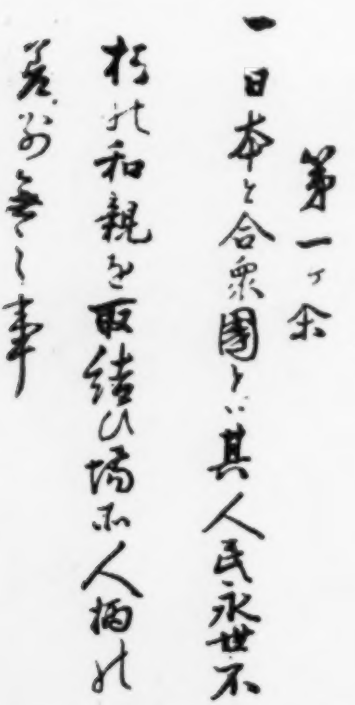

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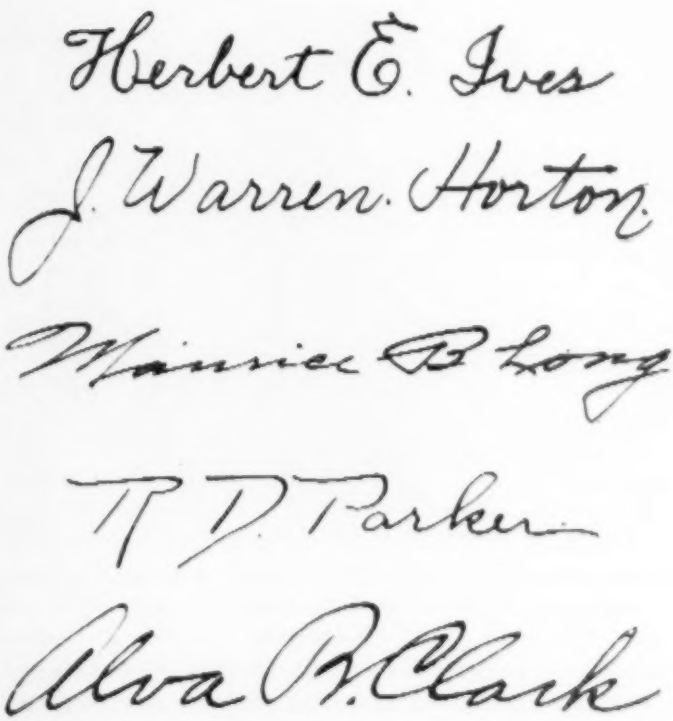
variable diaphragm in an optical system through which light from an appropriate lamp is passed. The light after passing through this "light valve" falls upon a photographic film and builds up a picture in narrow adjacent strips.

In order to synchronize the rotating cylinders at the two ends of the line use is made of synchronous motors. These are driven by a master tuning fork, impulses from which are sent both to the apparatus at the sending end and to that at the receiving end.

The picture transmission system as just outlined calls for what is ordinarily described as direct current transmission for the picture signal and for a separate communication line to handle the synchronizing pulses. Telephone lines are not ordinarily set up for handling the low frequencies which a direct current picture signal would involve, and it is furthermore uneconomical to use two separate circuits for picture and synchronization signals. For



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these reasons, both the picture and synchronizing signals are impressed upon carrier currents of voice frequencies suitable for transmission on ordinary telephone lines. The picture signals are carried on a frequency of approximately 1,300 cycles per second, the tuning fork impulses on a carrier of approximately 400 cycles per second. These alternating currents are both sent over the same line and are separated from each other at the receiving end by means of electrical filters, so that the light valve and the synchronous motor each receives only its own proper current.

In the system as now in operation the picture to be sent is placed on the apparatus in the form of a positive film transparency of size 5″ x 7″. The pitch of the screw which provides the rotation and translation of the film is 100 threads per inch. Pictures of this size and grain are transmitted in approximately seven minutes, and transmission may be made simultaneously to a number of

A THUMB PRINT SENT AND RECEIVED BY TELEPHONE, ENABLING LONG DISTANCE IDENTIFICATION OF CRIMINALS.

points, as for instance from Washington to New York, Chicago and San Francisco, as was done at the inauguration of President Coolidge, March 4, 1925. The picture is received as a negative, from which any number of prints can be made by ordinary photographic methods for distribution to newspapers or other customers. By working from wet negatives and using the transparency film at the sending end while still wet, the overall time of picture transmission may be kept below half an hour; the greater part of the time is consumed in the purely photographic operations.[1]

Pictures transmitted in the manner described meet with a number of uses. The widest use at present is in the newspapers, which are now able to show, in a few hours, pictures of events happening at the other side of the continent. A vivid illustration of this use was furnished at the time of the Santa Barbara earthquake, news of which appeared in the New York papers in the evening while the following morning papers had a full pictorial record. Another large field of usefulness promises to be in connection with police identification work, not only in transmission of photographs of

[1] For a more detailed description of the method and apparatus here discussed, see "Transmission of pictures over telephone lines," H. E. Ives, J. W. Horton, R. D. Parker and A. B. Clark, *Bell System Technical Journal*, April, 1925, p. 187.

wanted individuals but of their finger prints. Practical trials have shown that electrically transmitted finger prints may be identified within a few minutes of reception, thus making it possible to identify suspects who, under ordinary court procedure, could not be held long enough for the ordinary methods of communicating this information. Medical information, such as X-ray photographs, electro-cardiograms and other information on which a specialist can make quick diagnosis lend themselves readily to transmission.

The fact that an electrically transmitted picture is a faithful copy of the original, offers a field of usefulness in connection with the transmission of original messages or documents in which the exact form is of significance, such as autographed letters, legal papers, signatures, etc. It would appear that this method might under certain circumstances save many days of valuable legal time and the accumulation of interest on money held in abeyance. For these reasons, it is thought that bankers, accountants, lawyers, and large real estate dealers will find a service of this kind useful.

Advertising material, particularly when in the form of special typography and drawings is often difficult and costly to get to distant publishers in time for certain issues of periodicals and magazines. A wire service promises to be of considerable value for this purpose. Miscellaneous commercial uses have been suggested. Photographs of samples or merchandise, of building sites, and of buildings for sale may be mentioned. The quick distribution of moving picture "stills" which is now done by aeroplane is one illustration of what may prove to be a considerable group of commercial photographs for which speedy distribution is of value.

FOSSIL LOGS AND NUTS OF HICKORY

By Dr. E. L. TROXELL

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ALTHOUGH fossilized or petrified wood is common enough, yet the paleontologist is always delighted when he can secure evidence from the plants on the living conditions of the animals of past time. Especially in the Tertiary rocks of the Western Plains is the absence of plant remains notable, not because they did not exist at that time and place, but because they were not often preserved.

In the summer of 1923 I was sent by Professor Lull, director of Peabody Museum, to search for fossil vertebrates in the old hunting ground in northwestern Nebraska; while there I was told of a hill where hickory nuts and pieces of wood were to be found.

The discovery of the site was first made by Mr. Dan Jordan, a ranchman, and the place was visited by the paleontologists, Messrs. Hatcher and Peterson, some twenty-five years ago. In a small group of hills on the school section, about five miles north of the ranch-house of Mr. Tom Plunkett, Harrison, Nebraska, a small basin has been formed which drains out to the northwest. The present contour of the hills cuts through the old strata, laying them bare and exposing in the section the fossil logs and bones, long concealed.

The layers of rock belonged to the so-called Titanothere Beds of the Early Oligocene Epoch and were briefly mentioned by Hatcher[1] in 1900; they contain many logs of silicified and calcified wood, together with the internal casts of hickory nuts, beautifully preserved. At times parts of the shells are found, but these, too, are completely mineralized.

While much has been written about the hackberry seeds (*Celtis*), little seems to have been known about the presence of hickory; it was with especial delight, therefore, that these specimens were rediscovered. In spite of the fact that the nuts vary considerably in size, the further fact that they were found grouped in an area of narrow limits makes it appear probable that they came from a single tree.

Hicoria is well known in earliest Tertiary and again in the Miocene and Pliocene, and fossil nuts have been discovered in the Pleistocene formations. Certain species of the genus have been found

[1] Hatcher, J. B., 1900, *Science*, n. s., Vol. XII, p. 720.

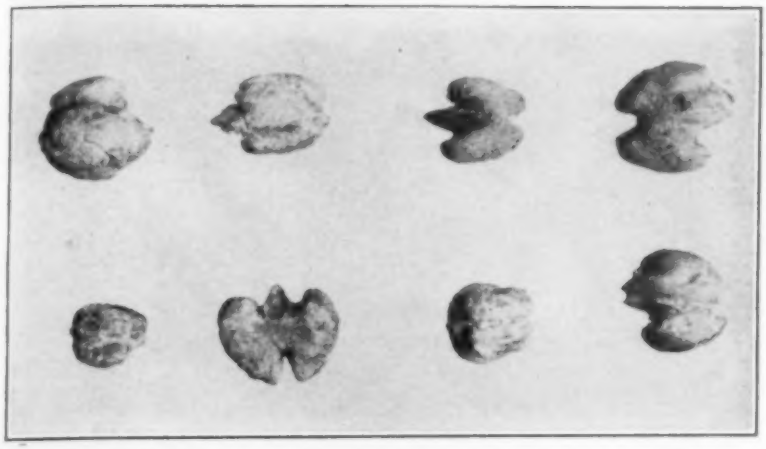

FIG. 1. Fossilized hickory nuts from the Oligocene of northwestern Nebraska. These consist mostly of internal casts, but in some of them parts of the shells are to be seen.

in the coal beds of the European Oligocene, but its widest extent in the past was in the Miocene of Europe and North America. The present-day distribution is limited to southern and eastern North America and to eastern China, but in Tertiary time the hickory existed in Alaska, over all the United States, Greenland, Iceland, Europe and probably in other parts of China as well.

FIG. 2. Hickory logs of Oligocene time. The longer section measured about twelve feet; the shorter one, now in Peabody Museum, was six feet long and more than a foot in diameter.

FIG. 3. The basin, in a small group of hills about fifteen miles north of Harrison, Nebraska, where the fossil logs, nuts and bones were discovered.

The hickory, next to the black walnut, is said to be the most costly of our American woods. Because of its hardness, strength, toughness and stiffness it is unequalled in the manufacture of spokes, tool-handles and the like.

Beside the plant remains we were able to secure the fossil bones of a half dozen different animals—*Mesohippus, Trigonias, Hyracodon, Brontotherium, Leptomeryx* and *Hoplophoneus.* We have information here which forces us to modify the widespread conception that the Oligocene was a period of great aridity. However, Berry tells us that the true hickory, as contrasted with the pecan hickory, grows slowly in a temperate, dry soil.

We picture in our imagination, in that corner of Nebraska, the setting of a scene some millions of years ago; the large hickory trees sheltering, on a hot day, an assemblage of odd-toed ungulates, the titanothere, rhinoceroses, the little three-toed horse, together with the deer-like *Leptomeryx;* and overhead a cat lying on one of the branches, ready to pounce down on an unsuspecting victim, to disturb the general tranquility.

THE SERVICE OF STATE-SUPPORTED AGRICULTURAL RESEARCH

By SIDNEY B. HASKELL

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FIFTY years ago was established the first of our state-supported agricultural experiment stations. These now are the main agencies in the several states for the conduct of research with reference to agriculture. The first appropriation was small—somewhere between three and four thousand dollars. From this small beginning the work has won a large measure of public support. There is now at least one such station in every state, and the total expenditures amount to over ten million dollars annually. Six million of this sum is appropriated directly by the several states. This is a large total. It is important that it be properly expended. This, indeed, is, as I understand it, the problem under discussion to-day —that of striking a balance between the cost of this state-supported agricultural research and the benefits from the investment.

Problems of control of plant and animal disease, of the maintenance and increase of soil fertility, of the breeding of plants and animals make up the major part of the programs of these stations. Not until quite recently have the states enlarged their field to include studies in farm management, on distribution and marketing of farm products, on the purchase of farm commodities and on the manufacture of agricultural products. Even more recently has there been formal recognition of the fact that in the study of social factors influencing farm life there may be a worth-while research investment. For these several reasons, therefore, evaluation of the work of the agricultural experiment stations must be on the basis of the older production projects, some of which are fairly complete, rather than on the newer work which has recently been undertaken.

For my first illustration I can do no better than mention the work of the Iowa Experiment Station with the oat crop. Thirty-five years ago, after some rather disastrous experiences both of the station and of Iowa farmers, the station reported as follows:

> From the frequent partial failures of our oat crops on account of rust, and the rapid deterioration of good varieties which we have imported from the best oat countries, we can draw no other conclusion than that Iowa is not a good oat state.

Compare this depressing picture, portrayed evidently in a moment of discouragement, with a recent publicity statement coming from the same state:

> It is estimated that over 11,000,000 more bushels of oats were grown on Iowa's 5,774,000 oat acreage in 1924 as the result of careful selection of varieties and their adaptability to soil and climatic conditions in the various sections of the state. A recent survey disclosed that about 46 per cent. of our oat acreage in 1924 was made up of four varieties: Iowa 103, which seems better adapted to southern Iowa; Iowar, which develops more favorably under the conditions in the northern counties; Iowa 105, which has a short stiff straw and is recommended only for very rich soils; and Iogren, a medium late maturing variety, which has been outyielding home grown varieties and which is expected to meet with considerable popularity.

Now to a Massachusetts man the figures cited above are rather startling. They represent a single field of oats equivalent in area to the whole state of Massachusetts, allowing nothing for roads or building sites or cities or forests—simply one vast oat field—and this in a state which was believed to be unfavorable to the production of the crop. The present development of this enterprise in Iowa is due in large degree to a vast amount of work done by the station—first canvass of the world to find the most promising varieties, then field tests of these varieties for the purpose of weeding out the poorer sorts. On this as a basis came formal breeding in the attempt to combine the best which the world afforded, to "synthesize" the oat best adapted to Iowa conditions. Supplementing this was work on control of the diseases to which the oat crop is subject, considerable work also on the problem of soil fertility. The final answer is given above. It is beyond me, however, in the short time at my disposal, even to attempt to estimate the cost of the research work which has contributed in making possible continued culture of the oat crop. Likewise it is difficult, if not impossible, to determine the benefit received by Iowa from research of other states and from that of the United States Department of Agriculture or the influence of Iowa research in other oat-growing states.

I present the foregoing as an illustration. I have decided to rest my case on a crop of less total significance, but one with which I am more familiar, and portray in rather great detail the steps which made possible a successful research and then attempt to show the dividends which are accruing and which for years will accrue from such work.

Beginning in the spring of 1918, the Maine Agricultural Experiment Station, in cooperation with the Bureau of Plant Industry of the United States Department of Agriculture, undertook a cooperative research on the transmission of the so-called mosaic dis-

ease of the potato. The disease had been definitely recognized in the state in 1912, had shown itself to be destructive, had come from no one knows where, and had been in the state no one knows how long. A countrywide survey in 1913 showed it to be distributed throughout the country. Research established the fact that the common green aphid serves as the transfer agent for the disease in question. Since the project attained its objective it must be considered a piece of successful research. The fruition of the work, however, is the result of such a long train of studies and experimentation that it is impossible with any degree of justice to give credit to any single individual.

I do not know the money cost of this particular project. In any event it can never be more than estimated, for time clocks are not installed in our experiment stations and few of our workers realize that time cards may be valuable. I estimate the cost to the state of Maine as being between twenty and thirty thousand dollars, extending over a three-year period. Without doubt the federal government contributed a like amount. If so, and putting the proposition on the impossible plane of a mere profit and loss transaction, we have the total of sixty thousand dollars as the cost of this most minute bit of information—that the green aphid, in addition to occasionally injuring the potato plant by sucking its juices, also transmits the virus of a plant disease and carries it over from infected to uninfected and perfectly healthy plants. For the moment let us not quibble over the size of the bill, but assume it to be accurate. Now comes the question—was this information worth its cost?

To answer, I must go back in history and portray those conditions which finally resulted in this particular bit of scientific research becoming the capstone of an attack on a vital agricultural problem. As I do this, remember that the potato is a universally used vegetable food and that its cost is a significant matter to most consumers. Remember also that success or failure with the crop is a vital thing to the nearly three million farmers who grow the potato. Do not forget that for every acre of potatoes grown in this country—and annually between three and four millions of acres of land are cropped to this vegetable—there is an investment of human energy to the extent of at least five full working days. In many cases the time investment is much greater. All important is it to both producers and consumers that this tremendous investment be capitalized to the full.

The first scene in our drama is thirty-seven years ago, when two of our agricultural experiment stations, those of Maryland and Vermont, both newly born and still wobbly on their legs, cooperated

in a study of influence of environment on seed stock of the common white potato. Starting with seed from the same source, the stations annually exchanged a part of their seed product, so that the two lots could be grown side by side under both northern and southern conditions. With the first year's crop, differences were slight. By the time the third crop had come to maturity, they were large. For some unknown reason the Maryland grown seed had degenerated—had literally "gone to pieces." Thus one of the earlier of our field experiments established a prejudice in the minds of potato farmers in favor of northern grown seed. That prejudice continues to the present day.

Very shortly was established an array of facts important to agriculture—that seed degeneration in potatoes is a vital matter; that in all southern districts it is very rapid; that it is less, possibly non-existent, in the north. Gradually pathologists came to recognize that in so-called degenerated seed potatoes are conditions which indicate disease. Even to-day they do not know the causal agency involved. Because they have failed in isolating an organism, and because it is transmitted through the tubers, they call it a "virus" disease. Degeneracy in seed stock or the "running out" of varieties is the agricultural problem which was solved in part by the research in question.

The second scene brings us to 1913, when Dr. Orton, of the Bureau of Plant Industry, an expert in plant pathology, suggested certification of potato seed plots as a remedy. This suggestion was based on observations made on German practice in potato culture. In its essentials it requires that seed be grown in a separate plot, instead of being taken from the general field or sorted from the general crop. These plots are to be grown under expert supervision, are to be rogued at intervals and held to certain definite standards. Acceptance of certification was an enormous step forward, yet the results from the use of certified seed were conflicting. Sometimes they were very good; at other times they were extremely discouraging. Sometimes the seed field would seem to be without blemish, roguing would be practically unnecessary, the yield would be all that could be asked. Yet, notwithstanding these favorable conditions, complaints would sometimes follow the use of its product for seed. Typically such complaints showed the development of mosaic or other virus disease in a strain thought to be free from infection. Somewhere was an unknown factor—we were ignorant of when and how these virus diseases were transmitted.

I can not do more than merely sketch the third scene, which is the line of attack developed by the Maine project. That the disease was transmitted through the tubers was already suspected,

although not proven. The research justified the suspicion. The effects of the mosaic disease were measured. The possibility of artificial inoculation was established, as was also its improbability under usual methods of handling the seed crop. It was proven that once a plant becomes diseased there is no chance of recovery for itself or for its vegetatively produced progeny. This fact holds true even though the virulence of the disease manifestation may be significantly influenced by environmental conditions. Utter failure met the attempt to control the disease through seed treatment.

The completion of the final phase of the project was dramatic. In the green aphid, an insect usually considered as being of little economic importance, was found the carrier of the virus. It was shown that a plant from healthy stock can be grown immediately alongside one from diseased stock, even with the leaves in contact, without contamination, if aphids be excluded. Only when the aphid goes from a diseased to a healthy plant is a spread in infection probable. By a most careful series of experiments one factor after another was eliminated until finally the case was proven against the aphid. This knowledge enables us to fill in the missing link in our system of potato seed certification. It shows that in addition to careful inspection and roguing and securing seed stock from sources known to be free from certain diseases, isolation of the seed plot is necessary in order that there may be no near-by diseased stock from which the infection may be carried. Applied in practice, the provision that the seed field must be certain distances from all other fields has made the difference between successful certification and that only partially successful. It has replaced a questioning attitude on the part of the growers with an attitude of increasing confidence.

It now becomes necessary to declare our dividends. The intensive field work was started in 1918 at Aroostook Farm, Presque Isle, Maine, this being a substation of the Maine Agricultural Experiment Station. The first report was published in the *Journal of Agricultural Research* in September, 1919. The Maine Agricultural Experiment Station published its report in 1920. It resulted in a change in the requirements of seed certification. Naturally the full effect of such change can not be measured until farmers generally appreciate the reason for the same and confidence in effective certification is awakened. I shall therefore take the year 1924 as a starting point in measuring our results.

Many states have made fairly accurate measurements of the yielding power of certified over common seed. The Maine station has itself made measurements of the injury done by the presence

of even mild infections of mosaic and kindred diseases. Even when the infection is so slight as not to be apparent to the casual observer, the loss in yield due to its presence may be as high as thirty to fifty bushels per acre. At the Connecticut Agricultural Experiment Station the gain in yield due to the use of certified seed has seldom been less than thirty bushels per acre, has often been double this figure. From these and other results, I estimate that ten barrels or thirty bushels per acre in round numbers may be taken as the normal expectation of the increased crop to be received from replacing the common seed by the certified product.

In 1924, 41 per cent. of the total Maine acreage of white potatoes was planted with certified seed, as against 16 per cent. in the previous year. This was an increase of over 34,000 acres, which on the basis of ten barrels increase to be expected represents an increased crop, a part of which was certainly due to the research in question, of 340,000 barrels. The fact of increased acreage of certified seed is in itself evidence of the increasing confidence in the tool of certification.

In the same year Maine farmers entered for certification 24,357 acres of potatoes; and 14,645 acres passed the final inspection, compared with 6,228 acres passed the year previous. On an average, one acre of Maine potatoes which are sufficiently good to pass certification will plant fifteen acres of commercial crop. The increase in commercial crop which may be expected to follow the increase in certified acreage in Maine in 1924 represents a total potential increased yielding capacity of well over a million barrels of potatoes.

But Maine is a political unit and is far from being a geographical or an economic unit. It is neither possible nor desirable to confine the results of scientific research to a single political unit. The whole northeastern part of the country raises seed potatoes, as indeed do adjacent provinces of New Brunswick and Prince Edward Island. In 1924, out of nearly 42,000 acres entered for certification from New York northeasterly through New England into these two provinces, 28,362 acres were finally passed. This is an increase over the previous year of more than 100 per cent., and a part of this—no one can ever know how large a part—goes back to the research under discussion and must be credited against whatever sum the investigation may have cost.

But the northeastern part of the country is not the only part which is attempting to produce disease free seed potatoes. The aphids are almost universal in their distribution. Severity of outbreak varies from year to year. In every potato-growing region

in the country this research is of significance. 1924 also is but a single year. As far as we now know, the white potato in the future as in the past will be a staple vegetable food. We are unable at this time to put any limit on the number of years over which the country will continue to reap dividends from its modest investment in this investigation.

The real value of work such as this can never be measured in money. It is an insurance of the country's food supply; it represents the means through which the food needs of an increasing population may be met. The best expression of the dividend is in terms of human energy consumed in growing the potato crop. Through controlling the source of seed and using the resources of science to prevent the diseases which cause degeneration, the producing capacity per hour of human labor spent in growing the crop has been increased. It is difficult to make a numerical expression of this increase—possibly it is as high as twenty per cent.; it can not be much lower than fifteen per cent. That this increase is permanent and is worth while will be admitted by all.

But there is a hidden fallacy in my argument. I have not dealt with the numerous other experiments and researches on the same agricultural problem, which failed to attain their objective. In the forty years which have elapsed since degeneracy in seed potatoes was first recognized as such, the problem has been attacked from many different angles. Experiment station literature contains many records of comparative tests on seed potatoes from different sections. Many stations have attempted to solve the problem through hill selection, some even through breeding. For a time it was generally believed that degeneracy was the normal and unavoidable result of continued vegetative propagation. Many of these researches were superficial, in that they attempted to determine facts and gave no attention to the basic causes of such facts. One and all they failed, although the final successful attack was based in part on such failures. A thorough-going discussion of our state-supported research problem must include estimate of the cost of the researches which failed as well as declare dividends on those which have been successful. Even so—if as a result of forty years' work the efficiency of the human beings engaged in growing a staple food product is permanently increased, can any one doubt its worthwhileness?

This brings us to the final stage of the problem—What means do we take, or what means may we take, to present the true facts to our main constituency—to the people who in the last analysis pay the bills?

Through all the usual methods of publicity—through bulletins and circulars, through articles in technical journals, through the public press, by lectures, occasionally over the radio, through personal contact—the facts have been promulgated and in some cases interpreted. The efficiency of any one of these methods, of all of them put together, is, however, limited by the generally accepted idea that the agricultural experiment stations are primarily agencies for the service of a single class. Only when dividends are declared in terms of a material thing, as increase in acres farmed, in product raised or number of people engaged in an activity; in increased price received for a product or in net value of the product, do our statements have the effect which we desire. We can make such statements; I have indicated a few of them. Intentionally, also, I have avoided going into them extensively.

Here we face a peculiar and most difficult problem. The extensive and rapid application of the results of the research just described has indeed resulted in the production of more potatoes, but likewise in a crop of decreased commercial value. Through increasing the productive power of seed potatoes, less land is required to grow our needed potatoes than would otherwise be the case. Through increasing the productive efficiency of labor employed in raising potatoes, fewer persons relative to our consuming population are needed in potato-growing than would otherwise be the case. It is even possible that the Maine Agricultural Experiment Station, working on funds contributed in part at least by the people of the state, has made a discovery which will show other states how their dependence on Maine-grown seed potatoes may be decreased. I am not prepared, therefore, to evaluate this great work in terms other than those indicated, *i.e.*, in terms of real human efficiency in producing a staple commodity. The great gainers are the people of the country. The primary gainers are those few farmers, more expert probably than their neighbors, who first profited by the production of certified seed.

Somewhere I have read the statement that when, years ago, shoe buckles went out of fashion in Europe, the buckle-makers starved. To-day in this country we are facing a somewhat similar situation. Research work carried on in the name of agriculture and for the benefit of agriculture has oftentimes increased potentialities of production without at the same time increasing the possibilities of a market. Both state and nation have gained immensely. So also have our better farmers. Somewhere, however, is a maladjustment in that we are still unable to capitalize a research such as this without causing suffering to certain portions of our population.

THE BIOLOGICAL ENGINEER

By Professor J. ARTHUR HARRIS
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HE would be a daring biologist who would attempt to compete with the historian in the evaluation of the contribution of the engineer to human progress. While the historian can not neglect the roads, the aqueducts and the great buildings—erected for the labors of the living and for the repose of the dead—of ancient times, much that is most remarkable in the application of natural forces and resources to man's needs has been accomplished in years so recent that it is fresh in the memory of men now living. We properly study the classics and the arts of ancient peoples for their beauty, but in admiring as well as enjoying the attainments of those older civilizations we should not forget that in our own day the engineer, by applying the results of scientific research, has harnessed and brought into human service those very natural forces before which primitive man trembled in fear and which in a higher stage of culture he deified. Accomplishment has not been limited to the utilization of enormous forces to relieve men and beasts of physical toil. Achievement has been almost beyond itself in the development of instruments of remarkable delicacy for the transmission, detection and utilization of waves of almost infinitesimally small energy value.

It is because of the attainments of the engineer in the application of the results of research in the physical sciences to human welfare that I desire to stress the possibilities of essentially the same methods in the biological fields and to emphasize certain ideas concerning the interrelationship of pure and applied science and of investigation and the practical utilization of the results of research, which have interested me for many years.

In suggesting that the day of the *biological engineer* is not far distant, it is proper to describe, even if we can not precisely define, the engineer, and to indicate his relation to research in pure science.

The engineer is of necessity preeminently practical. The investigator is of necessity to some degree a theorist. Unfortunately, theoretical is too often considered the antithesis of practical. In my own opinion the engineer is practical because his practice is grounded on scientific theory. The success of the engineer in dealing with the concrete is dependent to a considerable degree upon his knowledge of the abstract. We shall not go far astray in saying that the engineer is the agent for the practical application of ab-

stract theory. The investigator who describes the results of his researches in the general terms of scientific theory is practical because in due course of time the generalizations deduced from his observations, experiments and measurements may, and with a high degree of probability will, find useful application in human affairs. The engineer performs an immediate service to our highly organized society by the construction of some instrument for the conservation of natural resources, for the utilization of natural forces or for the increase of human efficiency. The investigator performs an ultimate service by providing the scientific data upon which the engineer depends for the economic usefulness of his work.

As one who has always been occupied with research in pure science, I desire to disclaim any attempt to minimize the work of the constructive engineer by overemphasizing the idea that he merely applies the results of others. In many cases it requires greater ability to use the results of research than merely to contribute to the amassed data of science. Men who have dealt with problems of pure science in the laboratory are broadened when of necessity they undertake application. I do wish to stress the idea that the labors of the two groups of men must be essentially different but supplementary. This necessity for differentiation or specialization of effort has been forced upon us by the growth of science. Because of the activities of an army of workers the recorded observations and generalizations of science are now becoming too extensive to be grasped by any single mind or any well-organized group of minds. As a result we hear much of the necessity for highly organized abstract services and research information service in the field of science.

In a way the growth of science may be likened to that of a coral reef. Only a small fraction of the whole structure is alive. In general, only a small part of the accumulated products of research are of immediate interest to the investigator. I hope I shall not be interpreted as minimizing in any way the work of the engineer when I say that he and the investigator are primarily interested in different strata of the series which constitutes the whole system of human knowledge. The investigator is primarily concerned with the loosely consolidated portions which are just being deposited as the result of current intellectual activities. It may even be said that the investigator is, to an unfortunate extent, influenced in his interests and sympathies, and even in his conclusions, by the scientific fashion of the day. The engineer, on the other hand, is primarily concerned with results which are so consolidated and tested that they can safely be applied in practice. We are beginning to see the baneful influence upon pure science of

the trained investigator having his time and his freedom curtailed by dividing his efforts between pure science and immediately practical projects. We are realizing, too, that many of the men who are assumed to be doing practical biological work in our federal and state institutions are not rendering their best public service because they are dividing their energies. Pure science and applied science would both profit if there could be essentially two groups of men, working in close consultation and often in cooperation, with the fullest mutual confidence and respect, the one group attacking fundamental problems, the other studying the ways and means by which both the long established and the current results of research may be practically utilized. To my mind the great problem of the engineer is to select from the mass of available scientific information the particular portions which may be economically applied to the uses of mankind. To see the needs and to select is a task for men of the ablest and most highly trained minds. Such men should have not merely the confidence of men of affairs but the respect and aid of scientific associates in research in pure science. In return, he should recognize clearly and publicly acknowledge the debt which his success in public service owes to his associates in investigation. The public which expects to profit by the work of the engineer should be given to understand by the engineer himself that such benefits can not be continuously forthcoming without support of the necessary antecedent work in pure science.

Primitive man was an animal living in simple and direct relation to the kindred but potentially lower animals and plants of his environment. In the course of that social evolution which we call the rise of civilization, this simple and direct relationship has been replaced by one of great complexity. Man's effort at self-domestication has resulted in a high degree of differentiation and specialization of social groups. In our modern industrialized society great masses of mankind have been entirely removed from personal contact with the living plant and animal species upon which all must ultimately depend for the essentials for existence. Even those fractions of mankind which do still devote themselves directly to the production of the raw materials for food and clothing pursue some one phase of a specialized, and in some instances highly organized, agriculture.

This development of an intensive and highly specialized agriculture is the inevitable result of two economic factors—the incipient pressure on the immediately available food resources of the world due to the growth of the world's centers of population, and the development of a rapid and world-encircling transportation system by the cooperation of the capitalist and the engineer.

Transportation systems characterized not merely by enormous carrying capacity but by swiftness of delivery and control of temperature during transit have not merely permitted agricultural specialization but, by making it a necessity, have introduced special problems of crop and animal production in every important country. They have had other weighty biological consequences. The congestion of people in cities has introduced many problems of food preservation, storage and deterioration, as well as of sanitation and hygiene. Consumption of agricultural products away from the land on which they were produced has introduced a problem of maintenance of fertility that bids fair to be of great importance. With rapid transportation has come increased danger of the introduction from one region into another of animal and plant parasites of domesticated plants and animals and of man himself—biological factors which may threaten the existence of great industries, of an economic importance to be written in terms of hundreds of millions of dollars. The development of tropical agriculture—the only practicable means for the production of many of the commodities which we to-day regard as essential—has become possible with the growth of shipping, but involves the problem of so modifying conditions of life near the equator as to make them suitable or at least safe for men belonging to races which have evolved under essentially different conditions. Earlier attempts at the construction of the Panama Canal failed, not because of the unsoundness of the work of the French civil engineers but because of the want of biological knowledge adequate for dealing with the great problem of sanitation.

The present century has been characterized by an enormous increase in the number of human beings living under the conditions of physical welfare which we associate with the word civilization. This twofold growth—an increase in numbers of individuals associated with an increase in the number of things which they feel essential to their well-being—has depended in the past upon the development of transportation facilities, upon the replacement of manual by mechanical labor, upon the analytical and synthetic skill of the chemist, upon the evolution of scientific medicine, upon an increase in the area of the world's surface under tillage, upon improvement in methods of crop production, and to some extent upon improvement in the inherent qualities of domestic animals and plants. There are reasons to believe that we are approaching, if we are not already in, an era in which continued growth must depend directly upon a wider application of the methods of science to our great biological problems.

What is essential for success?

First, more fundamental research in pure biological science, with a view to obtaining the precise quantitative information concerning animals and plants which is essential for successful application. Second, the development of a special profession of men of high ability and comprehensive training who shall find the difficulties of application a problem worthy of their best intellectual efforts. Men of this class will devote their attention primarily to a study of practical needs on the one hand and to the possibility of applying the results of scientific research to the meeting of these needs on the other.

I am not unaware of the great accomplishments of those who have specialized in the so-called practical phases of biological work —the pathologists, the agriculturalists and the husbandrymen for all the various breeds of living things upon which we depend for our physical existence. I am not unaware of the fact that the hydraulic engineer has filled an important place in sanitation, nor that the irrigation and drainage engineer has made a large contribution to the growth of our agriculture through reclamation. Neither am I unmindful of the part which the mechanical engineer has played in increasing crop yield per man by the development of agricultural machinery. But these are activities closely akin to conventional fields of engineering.

What we need in addition are men of such breadth of experience that they can make contacts with the practical agriculturalists, animal husbandrymen, transportation executives and public health officials on the one hand and with laboratory investigators on the other, with a view to finding the means of applying the results of the research of the one to the practical needs of the other; men of such vision that they can foresee future needs before they actually arise and prepare to meet them before they become acute.

Up to the present we as a nation have lived primarily by exploitation. The conservation and the development of our biological resources has, in my own opinion, hardly begun. The development of the temperate zone and the conquest of the tropics is only in part a matter of statesmanship, finance, industrial vision and engineering, as we now generally understand the term. It is in large measure a problem for the student of the biological sciences, who must present his results in the quantitative terms which make their practical utilization more readily possible, and for a type of man who is just beginning to develop among us—the biological engineer.

REASON, REVERENCE AND LOVE[1]

By Dr. DAVID STARR JORDAN
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IT is a great pleasure and a great honor to me to take part in the consummation of the work of my old friend, Dr. Frank Dyer, in the completion of this great temple, devoted to reason, reverence and love. And the greatest of these is love, as was said long ago, as love is "the greatest thing in the world." But perfect love can exist nowhere far from its two associates, reason and religion.

I have, this morning, the modest hope of achieving, not their final agreement, for that was assured in the work of creation, but a much less mighty result, that of their reconciliation in the minds of some of those to whom I speak.

Under the names of science and religion reason and reverence have been through the ages in recurrent conflict. I believe that this conflict has been the result of ignorance, a clash of new experiences with old tradition, the association with the name of religion of matters largely imaginary, or else belonging wholly to the province of science. Such discords are destined to pass away as our understanding of the universe and its ways becomes broader. Religion finds its center in the feeling of reverence and in the call of duty. There is nothing in the nature of knowledge that should conflict with this. There is nothing in the nature of religion which should inhibit the widening of intelligence or its extension to all within our reach in the universe in which we form a part. "The heavens declare the glory of God" far more in our own day than in the period when man's knowledge was limited to what was actually within the range of his eyes. When the spirit of religion is transformed into a system of belief involving statements of scientific or of historic fact, it becomes encrusted with superstition. To abate superstition is one of the chief functions of science.

The scope of science is the entire range of knowledge of the objective world. In its expansion it has the single method of tested and verified human experience, aided by such tools of precision as may be devised, the human reason being itself the most important. While imagination is one of the most useful of these tools, it can not of itself extend knowledge, but at the most indicate lines of exploration. It is a basal proposition of science that *we know noth-*

[1] Address at the dedication of the Civic Forum of the Wilshire Boulevard Congregational Church, Los Angeles, June 7, 1924.

ing until we find it out, and that no authority, actual or conceivable, can give answers to objective problems in advance of observation or experiment.

The scope of religion deals with human relations to the unseen powers around us, "the infinite conscious intelligence" that pervades the universe and our relations towards one another. The beginnings of religion like those of science are crude and modest, rising from fear of the unknown and invisible through fear, awe and reverence. Science or classified knowledge serves three fundamental needs of humanity. First, it enables man to help himself to the service of the forces of nature by adapting them to his purposes and adapting his purposes to them. This is "applied science" or engineering, using that word in its broadest sense to include sanitation of all grades. Second, science controls the conduct of life by tracing and registering the results of lines of action. This is ethical science, and the result of experience gives us the only test of right and wrong. Third, and not less in importance, science broadens the human mind and releases it from the cramping effects of reliance on tradition and on authority. Science opens the way to freedom, the only freedom there is, the release and development of one's own personality. "At the last, nothing is sacred save the integrity of your own mind." The scope of religion concerns our relations one towards another and to the unseen and unmeasured powers which surround us in the universe in which, in Huxley's words, "nothing endures save the flow of energy and the rational order which pervades it." Its beginnings, like those of science, are crude and narrow, rising from simple fear of the unknown and intangible through awe, reverence, worship and duty, culminating in helpfulness and purity, to visit the widow and fatherless in their afflictions, to keep one's self unspotted from the world.

Coordinate with the spirit of religion is the spirit of love, beginning far down in the scale of life, with conjugation of independent cells, but rising to be potentially "the highest development of altruism," the love of man and woman, the love of mother and child.

Evolution is "orderly change." Its way is the way of all things we know. Nothing is static in human life or in the universe about us, of which we can know nothing until we find it out, not think it out, but prove through observation or experiment its actual objective reality. Furthermore, whatever exists, an object or an event, has a cause behind it. All change is orderly, and we know of no source of order except an ordering or pervading intelligence. Hence evolution is but another name (and that none too well chosen) for nature.

And in nature the most elaborate, most perfect, most advanced result of orderly change is humanity. And in humanity the crown-

ing glory is in the mind. In the perfection of the mind, three features stand first, closely kin to one another, equally sacred, equally inborn and perennial, equally necessary, all three alike subject to suppression or perversion. These are reason, religion and love. Of these three, reason and its product knowledge stands as the regulator of emotion, and thus the backbone of conduct.

Science deals with realities, that is, with objective facts as impressed through the several senses on the nervous system of man. It is human experience tested and set in order. The conclusions of science are thus to be distinguished from memories (or past realities), fancies, superstitions, illusions or isolated facts not yet set in order. Fundamental to science is the conception that order exists throughout nature, and that there is no source of objective truth other than the human senses. Knowledge progresses as these are tested, verified and expanded through use of instruments of precision. The scope of science includes therefore all objective truth and it questions the validity of any other.

In the reality of the objective world, the integrity of science, the sanity of man are alike bound up. The distinction between objective and subjective, between reality of perception and illusion of nerve disorder, between fact and dream, between presence and memory, is fundamental in human psychology—is essential in human conduct.

The word religion is used in several different senses, these bearing a certain relation one to another, but by no means identical in fact or in spirit. From the standpoint of scientific analysis, religion is the instinct of fear, awe, reverence, worship, faith, duty, arising from the recognition of the gigantic forces which surround humanity, and of our desire to act in accordance with their supposed purposes in our pursuit of happiness.

In a historic sense, a religion is definable as the form in which the spirit of reverence has become embodied in human institutions. It is a system of belief, as well as worship, and as such, ceremonials, symbolisms, poetry, organizations and creeds have grown up around it either as aids or parasites or both. Thus an important branch of science is the study of comparative religions. The distinction between these two uses of the word is indicated in this epigram: "Religions die: religion, never."

Religions are historic and traditional. Religion, like hope, "springs eternal in the human breast," and is as likely to be found in dissent from a historic religion as in conformity to it. It is as natural and fundamental as the feeling of love to which it is closely akin. Both "spring eternal in the human breast," and both, as I have said, are alike subject to suppressions and perversions.

The name religion is also popularly used for dogmas, ceremonies, rites, symbolism, organizations, which have as their real or nominal purpose the aid to religious feeling, the control of religious activities or their concentration on the advancement of the individuals concerned or of the world at large. The word is also loosely used for any condition in any way allied with worship or propitiation of unseen powers. In so far as religion is compacted or crystallized into a system or a belief, it becomes at once encrusted with extraneous matters, poetry, hopes or superstitions.

In the strict or scientific sense religion is personal or individual. No one can take up the religion of another. In the historic sense one may join another's communion, enter another's cult or accept another's creed. Individual religion admits of no compromise. Organized religions are products of compromise, each communicant having a different mental picture of the central purpose if he rises to any conception at all. From the standpoint of science, the question as to whether any religion is true has no meaning. Religion itself is not concerned with statements of fact, either of science or of history. The actual problem is whether impulses, actions or opinions, called religion, work out for human betterment. "Pure religion and undefiled" is not concerned with theological subtleties, and a test of religion is the one offered by Jesus to Peter: "Feed my lambs."

It has been questioned whether the vague mythology of primitive man should be regarded as religion. But it is from crude beginnings that all higher powers or impulses arise. In our understanding human reason is developed from tropism and reflex action, simple reactions which in the lower animals or in human infancy precede the power of choice. In like manner we may include under the general term of religion all the various functions and impulses in the childhood of the individual or the race that lead upward to its higher manifestations. These constitute an obvious series: the highest stage involving an effort to conform to ways of righteousness established by a power higher than ourselves. At the heart of religion is the hope that by our conduct we may place ourselves in line with the will or the ways of the power we worship. In the earlier stages of humanity the invisible deities may be many in number, with varying powers and caprices, but the tendency of intellectual advance is toward the conception of a unified intelligence in a unified universe. This "rational order" which pervades all nature we can not describe nor circumscribe, for we can not speak of it in any term of human experience, nor can we grasp the character of that unconditioned source of matter and force to which with endlessly varied conceptions we give the name of God.

His "purposes," to use a human word, we know only by what He permits. In His sight (using again our limited phraseology) that is right which endures. That which seems to exist in the nature of things if proclaiming itself as powerful men have worshiped as divine, the more so if its origin and relations have been dimly understood. Force felt in darkness inspires awe. A god visibly built of a block of wood has never appealed to serious men. To the weak it is a tangible symbol of what they can not otherwise hold in mind. But it is the hidden force invisible, not the wood or stone before which men bow in worship.

So far as humanity is concerned religion and science are of the same age and must lead finally to the same end. We have been, each of us, thrust suddenly into a gigantic universe. Knowing nothing of the past, present or future, except as we can trace it by the dim light of our own observations and experiments and the recorded experiences of others, we find ourselves surrounded by creatures more or less like us and just as bewildered, and again encompassed by natural objects we can see and feel and by mighty powers we can neither see nor understand. And we find that unseen forces though not tangible are just as potent as the others and just as capable of tremendous disturbance of our daily actions. To stand in awe before the unseen is the beginning of religion, to attempt to find out how it behaves is the beginning of science. To be just and kindly towards our fellowmen and to be devoted towards our own family is the function of love, a sentiment as old as animal life, the traces of altruism appearing even in animals of a single cell and outrunning conflict through the world of animal life. "This world," says Arthur Thomson, "is not the abode of the strong alone: it is also the home of the loving."

Every robust human life is a life of faith, not faith in what other men have said or thought or dreamed of life, or death, or fate, not faith that some one afar off or long ago held a key to the riddle of existence, which is not ours to fashion or to hold. Not faith in mystic symbolisms which only a priest may interpret. Let us say, rather, faith that there is in the universe some force or spirit which transcends humanity, but of which the life of man is part, not the whole, something which is intensely real and which it is well for men to recognize, for to follow its ways brings effort and action, peace and helpfulness, the sole basis of happiness.

WILL THE FRENCH RACE BECOME EXTINCT?

By HAROLD G. VILLARD
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ALTHOUGH victorious in the World War and possessing the strongest and best equipped of all existing armies, the French people yet feel insecure. Their almost stationary population and Germany's actual and potential superiority in man power makes them apprehensive as to the future. If the French race should dwindle in number hereafter, as now seems likely, France's position as one of the world's great powers will become endangered.

At the outbreak of the French Revolution in 1789 France had 26,000,000 inhabitants, a greater population than was possessed by any other European country. This preeminence in point of numbers she lost to Russia after the Napoleonic wars, in which three million Frenchmen are estimated to have lost their lives. Despite this heavy toll of French manhood, the French people gained quite rapidly in number during the first quarter century after the downfall of Napoleon. About 1840, however, a change occurred. The French annual birth-rate, which had been over 31 per 1,000 inhabitants from 1801 to 1831, began to decline, while the death-rate decreased only slightly. The result was a marked falling off in the yearly percentage of growth of the French population.

When the Franco-Prussian War broke out France and the states which afterwards were included in the German Empire had about the same number of inhabitants. This equilibrium was upset by the cession of Alsace-Lorraine to Germany. Nevertheless, even after the loss of these since regained provinces, France had 36,190,000 people left and was still the third most populous state in Europe. But this rank she was unable to retain for long, because of the relatively insignificant additions to her population. Before the close of the last century the inhabitants of Austro-Hungary and the British people both outnumbered the French.

Between 1871 and the outbreak of hostilities in 1914 the population of Germany jumped from 41,000,000 to 67,800,000 or almost two thirds, and that of Great Britain from 31,556,000 to 46,081,000 or nearly fifty per cent. During the same period the French population rose from 36,200,000 to 39,800,000, a gain of only one tenth. Had that rate of growth continued unchecked these three countries

could have counted on doubling their population: Germany in 65 years, Great Britain in 87 years and France in 430 years.

This poor showing of the French was due to the small excess of births over deaths during the period in question. Indeed, in the seven years 1890–92, 1895, 1900 and 1907 more persons died in France than there were living children born, while the average gain in population between 1901 and 1913 was only 58,000 per annum. This slight growth was not sufficient to arrest the depopulation of the French rural districts, the number of whose inhabitants shrank from 24,868,000 in 1871 to 22,093,000 in 1911 or a decrease of one ninth. While it has been calculated that the average family in this country, which has a considerably higher birth-rate and a much lower mortality rate than France, must have 2.6 children to maintain the population of the United States at its present level, the census of 1911 revealed that the average French family had but two children as compared with 4.2 offspring in 1801, the exact figures being 11,696,663 families and 23,059,032 children.

Statistics prove that as many people marry in France as elsewhere and that the proportion of childless marriages is not abnormal. In the case of the United States it has been computed that one marriage in six is either sterile or leads to no live issue. In France 157 out of every 1,000 families were without living children in 1911. The lack of progeny in France was not due, therefore, to an inability to procreate children but rather to a systematic limitation of their number. After having brought one or two children into the world the majority of French mothers stopped having any more. Of the 11,696,663 households enumerated at the time of the 1911 census 7,432,859 or almost two thirds were found to have two children or less. While selfishness and a desire to evade the responsibility of bringing up children was a contributing factor, the main reason for the small size of French families has been excessive parental love.

Unlike this country, where sons and daughters are expected as a rule to make their own way in the world as soon as they have attained their majority, French parents allow their children no initiative and feel obligated to provide for their future. They also want them to rise in the social scale and, with this object in view, seek to establish their sons in some profession or government post and to endow their daughters with a handsome marriage portion. The fewer children there are the greater the likelihood of their aims being attained.

Moreover, France is a country of thrifty peasant proprietors, who cultivate small strips of land and who are passionately attached to the soil. In 1921, 5,219,464 independent landowners were enu-

merated in France, of whom over 2,000,000 owned less than two acres. The French Revolution, however, did away with the law of primogeniture. According to section 745 of the French civil code, a man's real property descends to his children in equal shares, irrespective of their sex. Hence peasants and small landowners who either want their holdings to descend intact or whose properties can not be advantageously further subdivided have every incentive to limit themselves to one child.

This equality of inheritance provision has been held by French writers to have been one of the principal reasons why the population of their country tended to become stationary before the World War. From that sanguinary conflict France emerged victorious but with the flower of her manhood gone. Within her former borders and without Alsace-Lorraine, 38,468,813 persons of French descent resided at the time of the 1911 census. In 1921 only 36,084,266 French citizens were counted in the same area, a decrease within the decade of 2,384,547 souls or one sixteenth of the purely French population existent in 1911. This loss was partially made good by the reannexation of Alsace-Lorraine, which contained 1,709,749 inhabitants in 1921 as compared with 1,874,014 inhabitants in 1910, when the last German census of these provinces was held. With Alsace-Lorraine included the total population of present-day France was only 39,209,518 in 1921 as compared with 41,476,272 in 1911. The population in 1921 consisted of 37,659,059 French and 1,550,459 foreigners.

Of the 2,000,000 or more French that were lost during the World War, 1,350,000 were killed in battle, while the decrease in the French birth-rate during the war period accounts for the remainder. In each year from 1914 to and including 1919, more people died than were born in France, the excess of deaths ranging from 53,327 in 1914 to 389,375 in 1918. When the war ended patriotic Frenchmen were urged to marry and to help make good this decimation of the race. If France is to live, her people must be more prolific, exhorted the press, while Clemenceau declared in 1919 that the war would have been fought in vain if the French women did not bear more children.

At the same time legislation was passed to facilitate the raising of large families. Money grants, preferment in appointment to official positions, reduced taxes and lower railroad fares were some of the rewards offered fathers with numerous offspring. Bonuses for married employees gauged according to the number of children were even introduced. But all these appeals and inducements have been without effect. The last census showed that French bachelors

numbered 3,000,000, while the French birth-rate is virtually the same as ten years ago. In 1922 and 1923 it was 19.4, last year 19.2 and in 1913, 19.1 per 1,000 of population.

Another disquieting fact for those who had hoped to see the French multiply faster after hostilities ended is that, although the population is about the same, thanks to the recovery of Alsace-Lorraine, the number of children born in France is now less than before the war as a glance at the following table will make clear:

Year	Births in France
1913	790,355
1920	834,411
1921	813,396
1922	759,846
1923	761,861
1924	752,101

The abnormally high totals reported for 1920 and 1921 were due to the unusual number of weddings that took place after the Armistice, which in many cases represented unions that had to be postponed on account of the war. The normal number of babies in France is about three quarters of a million per annum. But this yearly crop of new lives is insufficient to maintain France's population intact. If that is to be kept at its present level 900,000 infants a year must be born, as a prominent French deputy has shown in a recently issued pamphlet, provided, of course, that the mortality rate undergoes no change.

Although the French are not reproducing themselves, they have not as yet begun to die out. In the last three years, 1922–24, the excess of births over deaths in France was 237,666 or at the rate of 80,000 per annum. While no statistics are available on this subject, some experts are of the opinion that this excess of births is in a large measure due to the presence of several million foreign laborers on French soil whose home birth-rate is higher than that of the French native stock. Should conditions remain the same as now, however, the scale will before long be tipped the other way. For during the war years the French birth-rate fell off more than 50 per cent., which means a corresponding drop between 1935–40 in the number of young men and women able to marry. During these years or shortly thereafter, the French marriage rate will be halved, with the inevitable consequence of a like proportionate decrease in the birth-rate. Thus the slight annual gain that is now taking place in the French population will be more than wiped out a decade hence. Then the twilight of the French race will truly set in.

While the French people are barely holding their own in numbers for the time being, other countries are adding very largely to their population. Between the census of 1919 and the one held in June, 1925, the population of Germany rose from 59,178,185 to 62,474,872. Of this gain of 3,296,687 or 5.57 per cent., 3,252,200 was due to the excess of births over deaths. The estimated population of England and Wales was 36,800,000 in 1919 and 38,746,000 in 1924, an increase of nearly two millions in five years. Italy's population is mounting at the rate of 450,000 per annum, so that the Italians will soon outnumber the French if they do not do so already. Of all the civilized states France makes the poorest showing as regards excess of births over deaths, as is borne out by the following figures appearing in a recent issue of the *Journal Officiel* and which give the excess of births over deaths per 1,000 inhabitants during 1923 in the countries hereinafter named:

Country	Excess per 1,000
Holland	16.1
Italy	12.6
Norway	11.5
Denmark	11.0
Finland	9.9
Scotland	9.9
Spain	9.2
England and Wales	8.1
Switzerland	7.6
Belgium	7.4
Sweden	7.4
Germany	7.0
Austria	7.0
Ireland	6.9
France	2.4

Asked why his nation should for years past have stood at the foot of lists of this description the average Frenchman will cite as a reason the so-called "crisis in natality" raging in his native land and the disinclination of French women to bear more children. But, while to a certain extent true before the outbreak of the World War, this excuse no longer holds good. In the matter of bringing future citizens into the world French mothers are nowadays not far behind those of other countries. This is shown in the following table, likewise taken from the *Journal Officiel*. It gives the number of births per 1,000 of population during 1923 in fifteen of the European countries:

Country	Births per 1,000
Spain	30.4
Italy	29.1
Holland	26.0
Finland	23.7
Norway	23.0
Scotland	22.8
Denmark	22.3
Austria	22.3
Germany	20.9
Ireland	20.6
Belgium	20.4
England and Wales	19.7
Switzerland	19.4
France	19.4
Sweden	18.8

The above quoted rate for France is undoubtedly too high, as it has been calculated on the assumption that the French population in 1923 was the same as in 1921, whereas it was swelled during 1922 and 1923 by the net immigration over all departures of 323,000 alien workmen, many of whom brought with them their wives and children. But, even if allowance be made for this error, the French birth-rate shows up well. The truth is that in all civilized nations the birth-rate has been tending downwards for many years past, so that to-day Germany, England and France are in this respect not far apart.

This continuous fall in the birth-rate has been offset in most countries by a corresponding decline in the mortality rate, thus enabling the population to grow steadily though not in quite the same ratio as before. This statement does not hold good of France, however, which, with the exception of Spain, has the highest death-rate of any Western European nation, as the following table, first published in the *Journal Officiel*, makes manifest:

Country	Deaths per 1,000 in 1923
Spain	21.2
France	17.0
Italy	16.5
Austria	15.3
Germany	13.9
Finland	13.8
Ireland	13.7
Belgium	13.0
Scotland	12.9
Switzerland	11.8
England and Wales	11.6
Norway	11.5
Sweden	11.4
Denmark	11.3
Holland	9.9

In the United States, where living conditions are exceptionally favorable and the death-rate has fallen faster than the birth-rate, about twice as many people are born each year as die. In 1923 the corresponding ratio in England and Wales was three deaths to five births, in Germany two deaths to three births and in France seven deaths to eight births. Until 1900 Germany had a higher death-rate than France, but since then conditions have been reversed. In 1923 and 1924 more children were born in France than in England and Wales, although the populations of the two countries are within a million of each other. Despite the initial advantage of 34,545 more births the natural increase in population, that is, the excess of births over deaths, was during the last two years only 167,087 in France as against 570,533 in England and Wales. Because the latter country has been able to hold its death-rate down to two thirds of the French death-rate its population is increasing three and a half times as fast as that of France.

France's real cause for worry, therefore, is not her low birth-rate but rather her very high death-rate, which must be reduced if she would keep pace with other countries in the matter of population. As her birth-rate is low her death-rate ought to be also low, for the reason that the mortality rate in the first quinquennium of life is much higher as a rule than at any subsequent one until the age of sixty is approached. Thus in England and Wales the mortality rate for all ages in excess of five years was 11.04 per 1,000 persons living at those ages in 1913, while for ages under five years the mortality rate was 35.7 per 1,000. Any advantage that might be derived from a lower infant mortality is more than offset in the case of France, however, by the fact that in that country there are fewer children and young people and a larger proportion of aged persons than elsewhere. In 1911, for example, the average age of the French population was thirty years and that of the people in England and Wales twenty-five and three fourths years. The difference may not appear very great, but in comparing French with English or other mortality statistics allowance must be made for this variance in age composition. Although France possesses an older population the average duration of life there is shorter by some three years than in either England or the United States.

But infant mortality figures based on the number of children under one year of age dying in a given calendar year as contrasted with the total number born during the same time are directly comparable. As regards such figures France does not make as good a showing as England or this country. For instance, in 1923 761,861 children were born in France and 758,386 in England and Wales. Yet, although the number of the newly born was virtually

the same, 73,283 infants that had not attained the age of twelve months died in France during that year as compared with 52,362 in England and Wales. As France possesses on the whole a remarkably healthy climate it should not prove an impossible task to lower the infant mortality rate materially through the introduction of improved child welfare measures.

The death-rate from tuberculosis in France is much higher too than in Spain, Italy or Germany and is twice that of the United States and England. Of the persons aged between twenty and forty years in 1913, 6.93 per 1,000 died in France as contrasted with 4.43 in England and Wales. Nearly half of the French deaths were due to tuberculosis. The death-rate from this dread disease in France could be quickly cut down by abandoning the practice of herding young men in unsanitary barracks and by demolishing the germ-infested habitations in the old portions of French cities.

The higher general death-rate in France is also explained by the unsanitary conditions under which the great mass of the population live and their lack of personal cleanliness. In his book, "My Second Country," Robert Dell justly points out that in Paris (which is the most advanced in sanitation of all French cities) a large proportion of the houses are unattached to the main sewerage systems and are drained into cesspools. The French peasants live under filthy conditions, with animals in their houses, while there is no proper inspection of factories and workshops, which are terribly unsanitary. If this state of affairs could be remedied there is no reason why the age composition of the French population should not in the course of a comparatively short while approximate that of other peoples, for France's high mortality rate is not due to climatic, racial or other unpreventable causes.

However, to provide the French people with sanitary dwellings, a purified water supply, adequate milk inspection and to teach them modern methods of hygiene will require a very considerable expenditure. But France has no money available for such useful outlays, as disbursements for her huge military establishment and the interest on her crushing debt absorb most of her budget receipts.

The French would thus seem to have it in their power to decide whether they will increase in time in the same proportion as other European peoples or become ethnically extinct. They must improve living conditions at home or their ranks will continue to be thinned by disease as now and they will slowly but surely shrink in number. If they resolve to remain the world's foremost military power and to carry the burden of a great colonial empire with all the attendant sacrifices they cripple themselves from introducing

the housing and sanitary reforms essential to their survival as a great race. They are therefore confronted with a fateful decision.

Whatever their choice it is improbable that France will become depopulated hereafter. Only half as densely peopled as Germany or Italy, she has had to call in thousands of alien laborers to till her soil and to help develop her industries. At the close of 1923 the number of foreigners in France had reached 2,800,000. Of these 700,000 were Italians, 550,000 Spaniards, 500,000 Belgians, 400,000 Russians and 200,000 Poles. They constituted one fourteenth of the total population. But the French do not easily assimilate the nationals of Latin and other countries, few of whom elect to become French. In 1924 only slightly more than 3,000 foreigners became naturalized French citizens. The real peril confronting France is not depopulation but denationalization. Before many decades these alien workers and their descendants may outnumber those of true French extraction.

A ROMANTIC IN BENGAL AND IN NEW YORK[1]

By Dr. ELSIE CLEWS PARSONS

I AM a man of *magha,* for I was born under Magha, the tenth of the twenty-seven stars who were daughters of King Daksha. This is a dangerous star to start a journey on—on arrival you will meet with death, not in body, but in your plan or prospect; but Magha is a most auspicious star to be born under, meaning wealth and fame. Of a distinguished and prosperous man people will say, "He must be a man of *magha.*" In three ways I have become distinguished. Some people speak of me as the man who is a prodigy with numbers, others say I am a fine actor, others say, "There is the wonderful man who was initiated with his dead wife." I have had a very romantic life, but in wealth I have not yet succeeded, and my journey to America has not been successful.

My family lives in Dacca District, Bengal, in a village in the plains, the largest in the district, from ten to twenty thousand in population. We are Kasyathas,[2] our family (*padhati*) name is Bose. Ghosh, Bose, Guha and Mitra, these are the highest among the Kasyathas. These *kulin* Kasyathas came into Bengal in chariot, on horseback, on elephant-back, not as servants on foot. Datta is the fifth *padhati,* it is half *kulin.* Their ancestor was lacking in one of the nine virtues possessed of the others, he was lacking in reverence for the Brahmins. . . . There are in all one hundred and two divisions of the Kasyathas. My wife was Bal.[3] My great-uncle also married into her family. It was a glory to them, to marry with our family, as we are superior to them. When our

[1] With the narrator of this autobiographical account I was recently engaged in a systematic study of Bengal kinship terms and social organization. There was much of a biographic nature as well as cultural which was recorded during our acquaintance, and this part of the record is here given, in the mouth of the informant, an extraordinarily intelligent man, a conservative, and, from our point of view at least, an uncritical philosopher. To psychologist and ethnologist alike, such a combination of mental faculty and of cultural naïveté is of arresting interest.

[2] A division of the second highest caste, Kshattriya. The three highest castes, Brahmin, Kshattriya, Vaisya, are all Aryan, in Hindu opinion, the fourth caste, Sudra, are aborigines. Men promoted from the cow become Brahmin (good men, priests), from the lion, Kshattriya (heroic men, warriors and scriveners); from the monkey, Vaisya (lustful men, merchants).—"We differ from Darwin on this point," remarked Mr. Bose.

[3] A *padhati* of the Kasyathas. Padhati(s) are exogamous. Caste and sub-caste are endogamous.

men dine with them the first time, our men are paid for it, several rupees.

The descendants of my great-uncle and my grandfather live together. We live in joint family, the descendants [in the male line] of these two brothers. In Hindu society sons always live with their father; after he dies, the brothers and their families go on living together; the separation usually comes between brothers' sons. But in our case the brothers' sons have staid together. My father is the son of the older brother, but he is himself younger than the son of the younger brother, so he is not the Master of the family. My "uncle" is Master. He is an old man of seventy-five.

Usually a man as old as that has given up the responsibility for the household to a younger man, his younger brother or his son; but not so my "uncle." He has ruled us very strictly. He made all the disbursements for the household; he is a miser, too, and very unpopular in our village, indeed so unpopular that for the last five years he has not lived there, but away, in Munshigong. Formerly he was a school inspector. Now he is rich, and out of the service. Rich people don't need to take government service.

My "uncle" has given us our names. Usually several persons in the family suggest names for a child, in connection with the rice-giving ceremony, and one name is chosen; but in our family my "uncle" gives the names. He chose the name of my son and my name, Somesh Chandra, from Soma, Moon, isha, lord, Chandra, Moon. My son's name is Pinaki, from the musical instrument held by Siva. Pinaki was nicknamed Lord Canning—most people have nicknames—and he is so bright they call him Cunning.

The names of Siva or Vishnu appear in many names. It is auspicious for a man on dying to call on the name of God. So we give names of the gods to our children, that when we call them to us when we are dying we may be also calling on God.

My father's name is Umesh Chandra, Lord of Uma or Durga, *i.e.*, Siva, and Moon. My mother's? I can not say it, I will write it. We may not speak our mother's name. (He writes: Bilash Kamini, Luxury Lady.) This is an ugly name. My wife had a beautiful name—Sarajubala, Saraju is a sacred river, *bala* means girl. It is very romantic that when I was a little boy I fell in love with that name. I read it, and fell in love with it. I said that I would not marry any girl without that name, and my relations would say, "We will get a wife for you with that name." When I heard of a marriage I would ask the name of the girl, and when they told me, I would say, "I don't care for her name. She has not the right name."

The first wife of the cousin-brother we call *bara dada*, big brother, he is the eldest in our generation, had a pretty name, Pankajini, Mud born [? Water lily]. She was a poetess. Her son is now a student in the University of Chicago. She died when she was seventeen. Within six months *bara dada* married again. It is permissible for a man to remarry after the *sraddhu* ceremony [death feast and close of funerary taboos], that was held by us thirty days after death, but why did *bara dada* want to marry again at all? A Hindu woman who has lost her husband never marries again. Why should a man who has lost his wife?[4] I first asked that question when I was twelve, when *bara dada* married again. They said, "If your wife dies when you are married, you will marry again." I said I would never marry again, and I stopped speaking to *bara dada*.

At eight I was going to a Bengali school. Before that, in my fifth year, the family summoned our family Brahmin to perform for me the rite of "beginning education." Into my hand he put a pen and guided my hand into making letters. There are thirty-five consonants and fourteen vowels in Bengali, and I did not want to learn them. Finally, one day when I was about six, my father said that until I had learned those letters I could not come to a meal. In half an hour I knew them all. They said then that I would be a memory giant.

At the age of eight, my son will be taking sacred thread,[5] but I did not take sacred thread until I was twenty, when all the men in our family took it together, young and old. In Bengal until the last few years only the Brahmins took sacred thread, the mark of Aryanism. The Brahmins said that there were but two castes in Bengal, Brahmins and all the others, all, Sudras. Bengal Brahmins

[4] In "Lectures on Vedanta Philosophy," to the naïve quality of which there are supplementary illustrations in this story of one who is a Vedantist, Vivekânanda writes: "Take up one idea. Make that one idea your life. . . . Let the brain, the body, muscles, nerves, every part of your body be full of that idea, and just leave every other idea alone. . . . this is the way great spiritual giants are produced." (P. 70) S. C. B. is practicing this instruction, consciously, I think. Monogamy absolute is his object of concentration. Almost all subjects of conversation are brought around by him to this theme, of it he talks on all occasions, the most inopportune, and to all persons, the most indifferent. "All nations will have to believe in marriage like this," he says, but his talk is not of the nature of propaganda as much as pursuit of "concentration."

[5] It is of native grown white cotton, in three strands, each of three threads. One or even two strands may be loaned, in an emergency, but one strand must be retained. Sacred thread is never left off, except by accident when, deprived of sacred thread, one would not speak. The thread is touched while saying the mantras (prayers) belonging to it, to the goddess Gayatri, who dispels sins.

are very selfish. They are the least spiritual, too, in all India. They eat eggs, meat, fish and onions. . . . Now the Kasyathas determined to take sacred thread. They found that without it their fellow castemen outside of Bengal did not care to dine with them. Also it was argued that unless they had sacred thread they might lose the right to have their women, like Brahmin women, give evidence, in law cases, at home, through an intermediary; their women might have to go publicly to court. So Brahmins were paid large sums to give us sacred thread. Without the Brahmins we could not take sacred thread. They have to perform the ceremony. Besides nobody would revolt against Brahmins, because everybody believes in *khama* or reincarnation. You are a Sudra in this life for sins in your past life. If you live properly as a Sudra, you may be a Brahmin in your next life.

Well, at nine I went to an English school. Without an English education one can not get employment in India, and in our district one has to be learned to make a living. One day when I was ten or eleven the school inspector had asked our class to multiply three numbers by three numbers. I was the only boy out of the forty who could do it. He gave me more figures, four numbers by four numbers, and I did that. I told my family and they would try me on multiplying. When we had guests they would bet me the sweetmeats I was very fond of that I could not multiply their figures. So by the time I was twelve I could multiply fourteen figures by fourteen. Then I began to lose interest in developing this gift. Who are the great men of India, I was asking myself. They are the saints. I will become a saint. Of what value is my gift to a saint? I neglected my gift, rather I practiced austerities, for example, I would sleep without pillow or cover.

In H(igh) E(nglish) school I had double promotion three times, and graduated in seven years and went to the college. After two years I took the examination, and got a position in Calcutta as assistant accountant.

I was fond of acting. Our village boys organize themselves into actor companies, men taking the women's parts,[6] and give plays in vacation and are invited to perform at weddings. That was how I came to see my wife. I went in a dramatic company to the wedding of her brother. I saw her twice and then I learned that she bore my chosen name. She was beautiful, but her religious attainments I valued even more. . . . Since my wife's death I have not acted, nor will I ever act again, or even go into the theater. Before she

[6] There are no actresses in the village. They live in the cities, in special quarters. They are so hated and despised that if a man touches merely the shadow of one he will take a bath, even a low caste man, an aboriginal.

died I was going to take the part of a very beautiful man. I had a tooth missing and she advised me to have a tooth put in, the better to look the part. It was done,[7] but she died before the performance. So I said I would never act again. My friends say that by dying my wife spoiled their amusement.

My son, who is only seven, can act the three principal parts: the pathetic, the heroic and the comic, using the right tones and gestures—the female tone for the pathetic, a loud tone and sweeping gesture for the heroic, the gesture of twirling mustaches for the comic. We give him sweetmeats for his performance.

My wife, too, was a good entertainer, but of course she performed only at home, for her sisters-in-law. She would not sing or play before her mother-in-law. Even to talk with the superiors [seniors] in the family a daughter-in-law must have the consent of her father-in-law or her husband.

I saw my wife on the first night of her brother's marriage ceremonies. On the second night men and women are in different rooms. The second night we call Black night. The night of the wedding bride and groom sleep together, the second night they must not see each other, otherwise the marriage will not be fortunate. They say that Dasaratha, king of Oudh, saw his third queen, Sumitra, on the second night, and afterwards they separated. King Dasaratha was the father of an incarnation of Krishna.

When I went home, through friends, I told my parents that I had found my wife. I did not speak directly to them about it, for nobody speaks of getting married to their parents. A girl would never think of speaking of it. If she did, she knows people would call her shameless. "A girl of twelve, she talks about marriage with her parents! Shameless girl!" A boy would *never* speak about it to his father, he might speak about it to his mother, if he likes; a mother is more affectionate and familiar than a father.

I told my friends, "I am married already." My friends advised my parents to consent. "If you want your son to lead a worldly [household] life get him that girl," they said, "for never will he marry anybody else." I was their eldest son, I was twenty-one, it was time for me to marry, so they consented. Our wedding day was May 6. According to the almanac[8] of that year that was the most auspicious day of the year, and that month [lunar month]

[7] For my western tour I had two teeth put in the front of my mouth. When I return I will take them out. God did not give me these teeth; why should I use them?

[8] An almanac is published two or three months before April 14, New Year. As the almanac gives the auspicious days for ceremonies and for almost everything you have to begin, it is one of the most valuable things a Hindu can own.

is always auspicious. My wife was thirteen.[9] That is about the time nowadays that we like girls to marry. Not to have a daughter married before her menses is a disgrace and "second marriage," which is the ceremony after first menstruation, is always performed. A girl's first menstruation in her father-in-law's house is always assumed to be her first. My wife's second marriage was performed two months and a quarter after we were married, the sixth night after the appearance of the menses. Prognostication is made according to the date of this event. Of my wife it was predicted that she would be *patibiata,* a girl to whom her husband is god-like, an object of worship.

A girl's education is begun by her parents; it is carried on by her husband. He should be the first man she cares for. If she does not marry until she is sixteen or seventeen she may have been in love with some other man. Formerly girls were married at eight; that is still better for their education, and conservative Hindus would like to go back to that practice. But in those days nothing was paid for bridegrooms. The bridegroom himself made a present to the girl's family, and that was a good practice, for it was a sign that he would be able to support his wife properly. To-day the bride's father has to pay, sometimes so much, particularly for a highly educated bridegroom, that they have to wait until they can afford it. Sometimes even girls of twenty are not yet married. Money is paid to the bridegroom's father because he wants to be recompensed for the expense he has been put to in sending his son to an English school—an English education is very expensive.

Formerly young people used to arrange their own marriages—I was doing nothing out of our own tradition. To-day we have professional matchmakers, although family connections are also asked to make matches. In several cases I have been asked to do so. I know what the requirements are. My sister's sister-in-law asked me to arrange a marriage between her daughter and our father's sister's daughter's son. He was highly educated, he could speak English very well, he was very beautiful, they were rich, they were of superior *padhati,* but his father was a dead drunkard and so was his brother, perhaps he would himself become a dead drunkard. They did not live in joint family, they were selfish people. All

[9] Actually twelve years and seven months, as I was twenty years and seven months. We were born in the same month. In our case the astrologers were not called in to determine whether the signs of the zodiac we were born under were mutually auspicious. If the horoscope is inauspicious, showing, for example, that although sons would be born they would die, the marriage will not be made. Parents think of the future, the young people, if it were left to them, would not. They would say love is love. . . . In our case the matter was left to God.

this I told my sister's sister-in-law. She wanted me to make another choice. I proposed my wife's brother, Satishmohan. "Compared with the other boy," I said, "he is just as beautiful, just as white, he is rich, too, but he is inferior in *padhati,* and he is not highly educated. On the other hand, his people live in joint family, with much religious instruction." The girl was married to Satishmohan.

Also, I have chosen girls in three or four marriages. I can tell when a girl will keep her figure. Mostly after a girl has had even one child her figure changes, it is no longer beautiful. After my two sons were born my wife was just as beautiful as before. Figure, contour of the face and color are standards of beauty. Often in the same family one daughter will be white and the other black. In the case of the less beautiful, the darker one, more will have to be paid for a husband, or a husband of inferior *padhati* will have to be selected. Parents pay a great deal of attention to color. They know that it is inherited, particularly if both the parents are dark. If their daughter-in-law is dark, she may have a daughter who is dark and then they will be put to large expense in marrying off their granddaughter. Marry her they must, for no family with an unmarried girl is respectable. Suppose there are two girls in the family, the elder, dark, the younger, white, still the elder must be married first. Always the elder sister or elder brother must be married before the junior can marry. Although in the case of boys an older brother who does not want to marry can give his consent to his younger brother marrying. Among my connections this has happened twice. One man who is now over forty has not married, he is the richest man in his village, but it was his whim not to marry, and so he gave consent to his younger brother to marry. In another case the boy was feeble-minded. My father was his guardian and he would not consent to his marriage. The boy wanted to get married, and he kept sending matchmakers to see my father; but my father said that he would not make any girl so unhappy; she would see that in our family where all the men were intelligent and well educated and good earners only her husband was not, that would make her morose. So this boy had to give his consent to his younger brother's marriage. But at it my mother first married the elder cousin-brother to a cockroach by rubbing vermillion on the head of the cockroach. Whenever we see a cockroach now, we boys always laugh and say, "There goes our sister-in-law." It is a great joke with us.

We joke a lot. Life in joint family is very cheerful. Western visitors who go only to the cities do not appreciate how cheerful and happy village life is, nor how poor—since the English occupation. The Bengal staple is rice, and formerly one maund (80 lbs.)

of rice cost two anas (four cents), now the cost may be as high as a rupee ($3.00). Formerly people did not have to go to work outside their household. Each household was self-sustaining. Now they must get employment outside. And even so, they can afford, in many cases, only one meal a day. Many, many village people are always half-starved. Four years ago twenty million perished, mostly from starvation.

The rich men are almost all Vaisyas, the third caste, merchants, traders. The millionaires are bad men, mere tittle hunters. They subscribe large sums to what the British Government wants, for a tittle, they give nothing to humanitarian work. A Brahmin widow with a son seven years old went to one of these millionaires, a man I know, and asked him to let her have a few rupees a month to educate her son. He refused. "What credit is there in it for me?" he said, "Nobody would know about it." Another millionaire told me I should go to England and America to show Western people what a Hindu brain could do, to exhibit my mathematical gift, and he promised to finance my trip. So I talked about going, for two years. But he didn't pay, yet I had to go; for, wherever I went, my relations and friends would ask me, "Well, when are you going?" To save my prestige I had to go. But I had no money, my rich "uncle" was too stingy to give me any, and my salary as assistant accountant in Calcutta was small, only thirty dollars a month. From bidding contractors accountants can make as much as seven thousand dollars in one day. That I would never do, for I am honest. So I borrowed the money to travel, $3,000, from three men, expecting to make it back by exhibiting my gift.

I would lose my gift, my friends had told me, when I married. "You are very foolish to marry," they jested, "you have a great gift, you will lose it." I did not agree with them; that was not my idea of marriage. "Two halves make one," I said. "Husband is half, wife, half. It is the same soul divided in two." So, for the glory of my wife, I began again to develop my gift. From multiplying fourteen figures by fourteen which is my *natural* power, the power I had in a previous life, I succeeded in multiplying sixty figures by sixty figures,[10] and I did square roots up to the eleventh

[10] This I had reached to when my wife died. Since then I have not tried for higher figures. And when I return to India I will not calculate any more at all. It does not contribute to a saintly life. [It is an astonishing display in ordinary life. In less than five minutes Mr. Bose found for us the fifth root of 1,418,514,742,349; the quotient of 73 divided by 182 to several decimal places; and the product of 67,325,098 multiplied by 592,637, *giving the answers together*, at the same time. At the start, when I hushed the group of college boys who were setting the examples, Mr. Bose said quiet was not necessary, so one played the piano, another fired off a pistol, the others talked.]

root. While I was concentrating on figures, in the posture of meditation, my wife also practiced concentration, in a meditative posture. She would sit in the same room, she could keep her posture, which was a difficult one, for twelve hours. She sat cross-legged with arms behind back, right hand holding right foot, and left hand holding left foot. For four hours she could gaze up to her forehead, on the spot between the eyebrows. That keeps you from thinking of anything else. I can do that only for two hours. My wife in meditating would concentrate on my face, as now when I meditate I concentrate on the face of my spiritual guide (*guru*).

Before our second son was born my wife was ill. "What will you do if I die?" she asked me. "I will kill myself," I said. "That would be very wrong," she said, "strong men should not commit suicide. There is our son for you to make a man." She made me touch her and promise that I would live to take care of our children. Then my wife died, four years ago. She was twenty-two. She died in full consciousness, uttering the names of deities. . . . At the burning ground after my little son had lit the first fire, putting the brand on her mouth, two men started to hold me from jumping. I said, "Let me go. I will not jump. I am under promise to her. Otherwise you could not hold me, I would be too strong."

At the very moment of my wife's death I gave up eating meat, fish, eggs and onions. Rice I still ate, for the satisfaction of my family, to please my mother, five times a week. Widows may eat rice even more frequently; my widowed relations tell me that I have surpassed them even.

Now I desired to set out and visit the saints, to find a saint who would initiate me together with my wife on my left side—that is the position of a wife with us. So I asked my parents' consent. They refused, they feared I was going to renounce the world and that they would never see my face again. "You may go," they said, "but without our consent." Now we believe that whatever we do without the consent of our parents will fail. So I did not go; I knew that I would not find the saint I sought.

But I said to my parents, "You had best consent, or worse will happen." In a few months my second son died. As they were taking his body out to the burning ground I said to my parents, "You see what I feared has come true. Now lest further misfortune happen, will you consent?" They were afraid my other son would die, so they at last gave their consent to my going. . . . . The household was assembled. My mother gave me her blessing by placing rice and grass on my head; my sisters (my inferiors because my juniors) placed it on my foot; I saluted all in turn, touching

their foot, or having my own foot touched; from the leaf-covered water jar at the door I plucked a sacred leaf, and, uttering a *mantra* [prayer-formula], I passed out of the door.

I travelled over India—fifteen thousand miles by rail—and I saw thousands of saints. I found many with wonderful powers, saints who because they were always truthful knew the truth about everything and everything they said had to come true, had to happen; saints who were never envious, wanting nothing from any creature, and so no creature could take from them or harm them; saints who wanted nothing in the world and so everything in the world was known to them and they realized God; and saints who were very, very old, one was four hundred years old; but not one of these saints would undertake to bring my wife back and initiate us together. I felt frustrated. Finally I came to Hardwar, and there found Giri, who is the greatest saint under the Himalayas, and president of the association of saints at Haridar (Hardwar). He could talk to me in Bengali.[11] "Why do you wish to have your wife with you?" he said. I explained to him that my wife was advanced in the practice of meditation before she died, and that wherever she was she was still advancing, that I could not desert her, that all other women were as mothers to me. He was pleased with what I said and he agreed to initiate us together, on condition that what converse I had with her I was never to reveal. We were initiated together, in a cave. All I can say is that for a half hour I had great enjoyment, I was as happy as it is possible to be. . . .

Since then I have practiced meditation daily from two in the morning to six. I begin by uttering *mantras,* invoking Shiva. Then, without words, I concentrate on the face of my *guru,* in my mind, I mean of course, although I have his photo with me, together with my wife's. I have told my landlady when she sees no light in my room not to disturb me. I sleep only three hours or three hours and a half, some nights not at all, and yet in the morning I am not tired, I am perfectly fresh. During the past week I have slept only two hours. In sleeping posture your *kunda kundalini* (coiled), that is the life that is *coiled* in you, is in your abdomen. It is your duty to awaken this *kunda kundalini,* so that this snake will pass from abdomen to the soul space in the forehead, through rising in the canal in your back which we call *shushumna.* Ordinarily this canal is closed; in meditation it opens, and sometimes

[11] Other saints I could not talk with properly, not speaking Hindi, which is the general language, although it is not known as well as English, particularly in Bengal. There are five hundred different dialects in India, we are told. Even in Bengal we don't understand the talk all over. If people from Chittagong speak quickly they can not be understood at Dacca or Calcutta.

in sleep, when the snake peeps into it and we can then dream wonderful things. But ordinarily in sleep we are spending at a high rate, at thirty. Normally we are spending life at the rate of twelve (we live at *baramatra, bara*, 12, *matra*? times). The rate goes up to sixteen when we cry or raise our voice as orator or actor; a voracious eater spends at twenty; one running, at twenty-four; one lusting, at thirty-six. By the breathing exercise of *pranayama* (inhaling, holding, exhaling, at the ratio 1:4:2) the rate of spending is reduced, we control and prolong life. My *guru* has not given me this *pranayama*, and until he gives it I would not attempt it, it is very dangerous and causes insanity in those unfit for it. But my *guru* has given me the best posture, one that disciples of even twenty years may not have got.

I drink a quart of milk a day, that is all my diet. And now I weigh one hundred and twelve. The saints never eat meat, fish, eggs or onions, least of all onions. All these foods interfere with meditation, they are too exciting.[12] Widows, too, do not eat these things. At home I eat from the widow kitchen. The widow or fishless kitchen is kept so separate that you may not go into it from the general or fish kitchen without taking a bath in the tank, an "under water bath." This bath a woman has to take on rising before she can cook. It has to be taken, too, on return from a funeral or after touching by accident an Untouchable. Some people take an "under water bath" two or three times a day. . . . We can not bathe properly in the West. Bathing in this country we don't call bathing. Submersion is the only complete bath. . . . In this country we prefer a shower to a tub, there are germs in a tub.[13] Yes, everybody can bathe in the tank, even Untouchables, at separate hours. The water is dug down to, it does not run.

At home I drank water, except on Monday, which is the day of the week my wife died. On that day[14] at home and here, too, I take less milk, too, than usual, and sleep less. Since I set sail from Southampton, on September 21, [nine months ago] I have not touched a drop of water. I have not been thirsty here. In London I was thirsty, for on the steamer from India I lived entirely

[12] Besides, in the meat of both chicken and cow there are many germs of tuberculosis. Sheep and goat, physicians tell us, it is safe to eat.

[13] An interesting illustration of completely identifying cleanliness with godliness, and of how if the trait of exorcism is omitted, cleanliness as such may go, and I think does go, by the board.—E. C. P.

[14] Nor will I do anything on that day to bring me credit, like displaying my calculating gift. [I happened to ask Mr. Bose on a Monday to show his gift to some guests, and he declined, postponing it to the next evening. On another occasion I had proposed that we work together the day following—April 26, but that day was the fourth anniversary of his initiation and he had planned not to leave his room.]

on flour I brought with me. On the steamer from Southampton to Canada I ate one apple a day. The forty-five days I was detained by the emigration office I could not get good milk. It was thin and dirty. I weighed only one hundred pounds. I thought I was going to die. I wrote that to my people in India. They got very much excited. It was in the papers in Bengal, the way I was being treated in Canada. The emigration office wanted a bond from me. So finally the richest Bengali[15] in New York who owns two houses there, took my $500 and went on my bond in Canada. . . . If I took up political work in India my experience in jail in Canada would count. A sister government, Canada, keeps in jail for forty-five days a man from her sister government in India! . . . Five years ago I would protest about anything that was against my principles. Now I keep silent, I will not quarrel.

I told the officials in Quebec I would not take a job in America, so I can't work here, it would commit me to a lie. I am hoping that Mrs. ——— will give me the money to pay off my loan. I worry over it, although my brothers write, "Why do you worry? We are four brothers, we can pay it off." If Mrs. ——— gave me enough money, I could also leave my son and my parents provided for and devote myself to spiritual life. She might give me money to do humanitarian work for Untouchables. . . .

Some of the Untouchable castes have been agitating for the privilege of being shaved by the barbers. Ten years ago I made speeches for them. My voice is very powerful. I can control an audience of fifty thousand. . . . I have been told in New York that if you are taken for a Negro a barber may refuse to shave you. I have been into several barber shops to see, but I have not been refused yet. In London I saw that Hobbes, the great cricketer, had to eat in a room with the professionals, and gentlemen would not eat with professionals. Is that not caste?

In London I was very much surprised by the good manners. On the street people would show you the way, even going with you. I met no Englishmen who were not gentlemen. My people will not believe this when I tell them, for in India we meet no Englishmen who are gentlemen. There may be English gentlemen in India, but we don't meet them.

I met a gentleman in London called Brown. One time he said to me, "I trust you will soon become a Christian."—"Why?" I asked him. "Because the Son of God came to earth." But among us God himself came to earth. Foolish Mr. Brown!

[15] There are in New York about twenty-five high caste Bengalese.

I want to be back in India in October for Durgajuba. That is the greatest religious celebration of all India. Everybody goes home then. On that day even a Brahmin will embrace a Sudra. My younger brother will first salute me, then I will embrace him. All through the month when people write letters they say, "Accept my Durgajuba greetings."

On my return, the women in the neighborhood will *ululu*,[16] as they do in all ceremonies and for a distinguished visitor and for one back from an important journey. It is a very good thing to hear, it makes us feel solemn and religious. I may have to perform the rite of atonement [exorcism] which is done for any infraction of ceremonial or caste usage. My hair will be cut, and mantras said and money paid to Brahmins. What was not sacred has gone, now again you are sacred, is the meaning of this rite. When it is due, unless it is performed, a person is treated as an outcast, none will speak to him, nor allow him into the house. Anciently, it is said, Hindus could cross the Black Water without atonement, but I may have to perform the rite on my return from America.

[16] An inarticulate sound from the throat is uttered while the tongue moves rapidly from side to side of the mouth, the lips being protruded.

DEMOCRATIC LEADERSHIP

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I

THE spectacular universalization of the democratic form of government has not by any means silenced criticism of the democratic way of life. The basis of criticism has shifted, however, as democracy has passed from victory to victory in its world-wide conquest. Gone, for the most part, are those sturdy characters who once stood out openly against the popular advance. There is a frankness about Plato and his kind that one who lives amid the current strategy of indirection must admire. Plato charged outright and in the open that democracy was bad because in its madness it sought to equalize those whom nature had differentially endowed. He would have none of it, unless under duress. Aristotle, though more tolerant, was still frank in his criticism. And even on the very threshold of our century, Sir James Stephen spoke as a fearless and free man in declaring that "no room is left for any rational enthusiasm for the order of ideas hinted at by the phrase, 'Liberty, Equality, and Fraternity'; for . . . there are a vast number of matters in respect of which men ought not to be free; they are fundamentally unequal, and they are not brothers at all, or only under qualifications which make the assertion of their fraternity unimportant."[1] Writing a dozen years later, Sir Henry Maine,[2] whom the discerning student is likely to feel little more sympathetic than was Stephen, spoke much more softly regarding democracy. Its greatest merits, one gathers from him, are its internal inhibitions against its own success. Verily, the worldly prosperity of democracy has softened the tongues of critics, even though the hearts of many of them remain heavy and fearful.

Since Maine, it is only now and then that a lonely Faguet cries out in the wilderness his whole mind regarding the popular idol.[3] Even the old and disillusioned have learned from the racy wisdom of the young that, though you dislike the hand that feeds you, it is better to manicure than to bite it. There is pathos in Lord Bryce's conscious effort "to repress the pessimism of experience," as well

[1] "Liberty, Equality, Fraternity," p. 318 (1873).
[2] "Popular Government" (1886).
[3] "The Cult of Incompetence" (1914).

as a moral in the reason he assigns for it—"for," as he says, "it is not really helpful by way of warning to the younger generation, whatever relief its expression may give to the reminiscent mind."[4] We have come upon days in which it seems that the dearest enemies of democracy have sublimated their fear of popular violence and their love of private property and have articulated their sublimation as a deep solicitude for the health of democracy itself.

The most common form this solicitude takes at present is a lament over the poverty of democratic leadership. Democracy, in the estimation of these all too eager doctors, finds itself, like so many delicate mothers, unable to nurture its children to maturity. It must, therefore, in order to achieve its own ends, call in the skilful help of those who, drawing their wisdom from an unrevealed source, pine to spend and be spent for the welfare of this deserving patient. Even Faguet reveals to those who pursue his heart beneath his bellicose title—"The Cult of Incompetence"—a deep longing to save democracy by furnishing it gratis an aristocratic leadership. President Nicholas Murray Butler, of Columbia University, many years ago offered to America the same friendly service as that of Faguet to France. Knowing that "liberty is far more precious than equality, and the two are mutually destructive,"[5] he counsels us to "put behind us the fundamental fallacy that equality is demanded by justice"[6] and to see that "the United States is in sore need to-day of an aristocracy of intellect and service."[7] But the highest achievement in the art of indirection must be credited to those who in a vein of delightful irony call themselves humanists. With some qualifications, Irving Babbitt may be taken to represent their attitude.[8] Professing solicitude for democracy and setting out to cure its ills by providing a superior leadership, he praises democracy with faint damns until our whole social order stands subservient to an aristocracy the real nature of which is disguised by its being called a class of "workers." But it turns out that instead of being either manual or intellectual workers, they are "ethical" toilers, and the only work they do is to live upon the fat of the land and furnish society a noble example by merely being themselves, illustrious and idle. Manual toilers must humbly remember, however, that they also work who only stand and pose. This salvation of democracy through the proper leadership is what its author pleasantly calls substituting "the doctrine

[4] "Modern Democracies," I: ix.
[5] "True and False Democracy," p. 57.
[6] *Ibid.*, p. 15.
[7] *Ibid.*, 14.
[8] "Democracy and Leadership" (1924).

of the right man for the doctrine of the rights of man!" Verily such wily Antonies come to bury, not to praise, democracy. Were such men alone in questioning the potency of democracy to create adequate leadership, we should know how to deal with them. We should regard them either as strategists or as naïve men self-deceived into believing that the voice of their private interests is but the echo of humanity's need; and their plans, one and all, we should treat as destructive propaganda.

But the situation can not be so summarily dealt with, because there are among those who bewail this democratic weakness men who are at heart friends of democracy and exemplifiers of the democratic way of life. So we are deterred from making short ugly shift of our enemies by the surprising presence of our friends in their front line. When William James, who was a natural democrat, emphasizes leadership as being the crucial test for democracy, we are deterred from dismissing it as being entirely a false issue. And when Lord Bryce, who was intellectually at least a friend of democracy, not only accepts leadership as being the democratic touchstone,[9] but then concludes that democracy "has not enlisted in the service of the state a sufficient number of the most honest and capable citizens"[10]—we are given further pause. But when Professor W. E. Dodd, who is both a natural and an intellectual democrat, bewails the quality of leadership in our democracy,[11] we are forced to retreat from the fray and think the matter over.

II

And the faith of at least one democrat is not shaken by taking this sober second thought. Faith that is not blind corrects itself and renews itself by viewing alternatives. Now whatever may be the defects of democracy, the only possible alternative is of such a character as to renew faith in democracy, however poor it may be; for the contrast is at bottom between forging one's own ends—roughhew them how one may—and lending oneself to further the ends of another. This is really no alternative, for individuality arises only with the assumption of the responsibility of directing one's own life. And what will a man give in exchange for his soul? But even the gloomiest pessimist does not put the alternative quite so sharply. It is not a question of leadership *vs.* anarchy, but of better *vs.* worse leadership. It may be that those who cry up the need of leadership are demanding a type of leader-

[9] "Modern Democracies," II: 551.

[10] *Ibid.*, 562.

[11] *The University of Chicago Record*, X: 109–114.

ship that democracy not only can not produce but a type also that it does not want. Meeting this difficulty, let us make a distinction between traditional leadership and democratic leadership.

The contrast here intended is between the leadership of prestige based upon authority and the leadership of knowledge based upon facts. The one is a matter of status and may even be hereditary, the other a matter of insight and achievement. The contrast may be better brought out by taking each type where it flowers most luxuriantly—in absolute monarchy and in science.

III

The absolute monarch was once upon a time a leader in every department of life: giver of laws, setter of manners, establisher of religion. As a trivial current example of what once prevailed on a grand scale, consider the influence of the Prince of Wales upon current masculine style. It is said that at least one American clothing manufacturer almost faced bankruptcy recently by the sudden change of style attendant upon the royal visitor's taste. Generalize this case from manners to morals and from morals to politics, and you get the ideal leader of tradition: a man whose every word and deed and whim set a precedent, because he was he. Those doughty men of old who went always at the head of every procession—they were the grace and the flower of the old order. Often allying themselves with deity, they sometimes essayed in moments of supreme kingliness to order nature herself into subjection; and in the imagination of articulate admirers both the winds and the seas obeyed them. This philosophy of authoritative leadership idealized the all-or-none principle: one, an all-leader, the rest of mankind, altogether followers.

I do not mean, of course, to imply that in actual fact leadership has ever for any length of time rested on sheer arbitrary authority: even absolutism bears within itself fated seeds of a more humane order. There is in man that perverse loyalty to ethical form that makes the sheerest tyrant uneasy unless his authority can be displayed as resting upon right rather than upon whim or force. Slavery in America, for example, was first recognized as an unnecessary evil blamable upon the mother country and awaiting only an occasion to be remedied. But becoming economically profitable during the interim, it evolved into a necessary evil. Given time, any evil that is necessary ceases to appear evil at all. And so through the metamorphosis of a century slavery emerged in moral habiliment, christened by Calhoun as a "positive good" and justified not only by the common welfare but also, as Professor Bledsoe

argued, by the good of the slave himself. The *malum in se* of one century became the *bonum in se* of the next: the right by might became the right in reason. Aristocratic leadership has never for long masqueraded as arbitrary. Indeed it has been at pains always to perfect techniques for preventing this. One simple way has been to assume that most men do not know what is good for them. If religious sanction can be so used as to content common men with the belief that "it is not in man that walketh to direct his steps," the rest of the way is easy for aristocrats. One of Plato's subtlest devices for guaranteeing inequality was thus the founding of leadership upon insight so esoteric that only a very few could ever discover the common good. Plato's justification for his philosopher-kings is the common justification the world over for the leadership of authority: superior wisdom has been vouchsafed to the few. Follow them and be happy, desert them and be damned. The easy way with dissenters is to declare, with Jonathan Edwards, that discontent with the established order is the surest mark of those foreordained to damnation. To disclaim against social injustice is in some governmental democracies still a jailable offense.

Spite of all devices, men have of course always questioned the bases of such leadership—indirectly when it was not safe to do so directly. When Socrates was told by the young Euthryphro that the gods constituted the celestial Supreme Court on all questions of morals, he queried searchingly as to whether an action is pious because pleasing to the gods or pleasing to the gods because pious. And the Middle Ages—when to challenge authority directly was not prudent—sought to resolve the question as to whether divine leadership was of the prestige or of the knowledge type; for of course the quarrel between the Franciscans and the Dominicans as to the primacy of intellect or of will had precisely this meaning. Given a geographical habitation and an earthly name, the controversy was over the relative merits of absolutism and democracy. Thus vaguely but surely did coming events cast their shadows before.

IV

The arrival of democracy, accompanied and reinforced by science, ought to have changed this conception of leadership; for it is perfectly obvious that leadership in science is of an altogether different mold. That the old notion of leadership has disappeared so slowly is, however, not without explanation. One indeed ceases to wonder at its persistence in democratic societies when he remembers on what absolutistic foundations modern democracy was built. Be it remembered that both in America and in France we built

upon natural rights and self-evident truths—that is, upon a foundation that could not be questioned without branding the questioner either a fool or a dishonest man. This was well enough as protection against our enemies who had made the logic, but it left no way for friendly engineers to safeguard the foundation against the inevitable wear and tear of the inexorable years. Foundations laid outside the domain of reason are not subject to repair and reconstruction by reason. It is significant that the two modern countries that built in dead earnest upon natural rights initiated democracy only by revolution.[12] Utilitarian England was able to come to the same pass by discussion rather than by bloodshed. Fighting is indeed the only way to end an argument the major premise of which is that your opponent is a fool. Renouncing the efficacy of human discussion for the certainty of natural rights and winning our initial success only by the ordeal of battle, we have continued the precedent by believing in a "manifest destiny" apart from the guarantees of human intelligence. Building beyond our resources, we have relied on occult and transcendental agencies to see our project through. Our susceptibility to, and even partiality for, a leadership that rested upon prestige drawn from esoteric sources have thus been but a piece with the other dependence we have placed on vague authoritarianism.

The foregoing philosophic reason for the longevity among us of an outgrown conception of leadership is reinforced by a commonsense reason based upon persistence of a deep illusion of childhood. Adults mediate the physical environment to childhood, and impress the child, his confidence once gained, as being far wiser than they are. This dependence upon the funded wisdom of another in moments of personal trouble is so easy a way of life that in most of us it long outlives childhood. One does not have to be a Freudian to understand how the child pursues this eidolon from parent to teacher, from teacher to hero, from hero to heaven. Our emotional nature hankers after the departing dream of omniscience long after our intellectual nature is content to give it up as another dear but dead illusion. So long as men cultivating this illusion, as in orthodox Christianity, demand as compensation for human loneliness a "friend behind phenomena" and as compensation for personal fallibility an omnipotent, omniscient leader, so long they are not prepared wholeheartedly to accept such sheer experimentalism as democracy has had to content itself with as a foundation. The acceptance of the democratic hazard is hindered

[12] For an elementary, but very stimulating, discussion of this point, see Columbia Associates, "Introduction to Reflective Thinking," Ch. IX.

also by that human inertia that makes it comfortable for one to lie back on his oars in the comforting belief that another wiser than he is guiding the craft aright. When such comforting phantoms are slain in one form, they return in another guise—like the hero of a once popular ballad who, when his legs were shot away, fought still upon the stumps. Eternal vigilance against these spurious hopes is the price democracy must ever pay for its liberty; but that such vigilance taxes human nature to the limit is seen in the lingering way democracies say good-bye to the ideal of absolutistic leadership.

V

It is, I think, the persistence of this outworn conception of leadership that accounts in the main for our disconcerting discovery of some of our friends in the front line of the advancing enemy. Both Lord Bryce and Professor Dodd, for example, show contamination with this older ideal by their emphasis upon *political* leadership as being the type by which democracy is to be judged. Lord Bryce goes so far as to say that democracy should denote no more than a form of government.[13] Professor Dodd, though clearly having a feeling for the contrast between democracy as a form of government and as an ethical way of life,[14] nevertheless turns all too easily to judge democracy by the kind of political leaders it has produced. Taking such men as Jefferson, Lincoln and Wilson as the flowers of our democracy, he bemoans the fact that "only once in half a century or so does there appear a master leader."[15]

This common predilection of men like Bryce and Dodd for regarding political leadership as of typical, if not of superior, importance in a democracy suggests strongly the presence in their minds of a lingering loyalty to a concept once universal but now—thanks to science—no longer in unquestioned repute outside of politics. The politician's infamy, to adapt Pope's famous couplet, does not grow out of the fact

> That he was the first by whom the plan was tried,
> But that he is the last to lay prestige aside.

Religious leaders whom one could have longest forgiven for allegiance to the old—so indigenous is the idea of authority to their profession—are going before the politicians into the kingdom of democracy, for speaking no longer as ones with authority, they are more and more content to join the scribes and sociologists in humbly

[13] "Modern Democracies," II: Ch. 3.
[14] *International Journal of Ethics*, 28: 465–84.
[15] *The University of Chicago Record*, X: 112.

following the trail of the facts. It is only the political leaders who still on principle point to themselves rather than to the facts, who depend upon mystic phrases uttered in pious tones, for attracting and retaining followers. Here and there indeed may be found a Borah who suspects that knowledge is not wholly alien to the political enterprise. Dr. Gosnell,[16] through his recent analysis of the leadership in New York of Boss Platt, has shown us, however, how deep-seated and persistent is the old type of leadership in current political life. Prestige is indispensable to its success, and the knowledge upon which it relies is more likely to be of men and of strategy than of ethics and economics. In the words of William Bennett Munro's new book,[17] it is "personality" that counts in politics.

VI

Science has discredited this type of leadership by the simple process of revealing that nature is too tough to be subdued by phraseology and of showing that it is impossible for any one man to know as much about the natural conditions of human welfare as these spectacular leaders of the past should have known to fulfil their promise. This science has done by throwing light upon both the nature and the goal of knowledge. To Plato—and his influence on history has been profound—the technique of knowing was non-sensuous if not indeed semi-mystic, the process led outside daily life into an unchanging world of pure Forms; and the objects of knowledge, once it reached its goal, were primarily for contemplation rather than for use. Science, however, has shown us that knowledge is not something got at by incantation, nor revealed the better to prestige and pomp. It has indeed abolished the royal road to wisdom through the backdoor of the mystic mind and has insisted that we seek knowledge by detailed observation through the front-door of our human senses. Along with this changed nature, science has given to knowledge a new goal.

Passing from the Socratic conception that knowledge is virtue and coming to the Baconian view that knowledge is power, man-come-of-age knows that it is not to palaver but to insight that we must look for control of the factors that condition our human living. So long as men had neither knowledge of nature nor the technique whereby to acquire it, so long had they to be guided, if at all, by fabulous reports of esoteric leaders who claimed, if not to have seen deity face to face, then at least to have looked in on his hinder-parts. Such an experience has constituted more than one Moses

[16] "Boss Platt, and His New York Machine" (1923).

[17] "Personality in Politics" (1924).

an authoritative leader for life. If one wishes to see how antiquated such a philosophy of leadership really is, let him but inquire what it is that constitutes Michelson a leader to-day in physics or Burbank a popular leader in horticulture. The older leader was strong in proportion to the ignorance of his followers; scientific leadership is strong in proportion to the intelligence of the followers. The strong tendency for all of us to think in terms of the one rather than of the other is explained by historic reasons, but is it justified by a comparison of the benefits mankind reaps from the two types of leaders?

Faguet has happily conceived the transition from the old to the new type—a change which he laments—as being the process of relegating the old men to the shelf. "An interesting treatise," says he, "might be written on the rise and fall of old men. Civilization has not been kind to them. In primitive times, as among savage races today, old men were kings. Gerontocracy, that is, government by the aged, is the most ancient form of government. . . . All this, however, is very ancient history. That which undermined the authority of old men was the book. Books contain all science, equity, jurisprudence and history better, it must be confessed, than the memories of old men. One fine day the young men said: 'The old men were our books; now that we have books we have no further need for old men.' "[18]

As a matter of fact the relegation has gone further still. The books that supplanted the old men have been in turn supplanted by the laboratory; and the old men who refuse to abdicate in its favor have been reduced from respected impotence to ridiculed relics. Hear Galileo's letter to Kepler, while the process was going on, regarding professors of authority, who in his day stood out against the new idea of leadership.

> Oh, my dear Kepler, how I wish that we could have one hearty laugh together! Here at Padua is the principal professor of philosophy, whom I have repeatedly and urgently requested to look at the moon and planets through my glass, which he pertinaciously refused to do. Why are you not here? What shouts of laughter we should have at this glorious folly! And to hear the professor of philosophy at Pisa laboring before the Grand Duke with logical arguments, as if with magical incantations, to charm the new planets out of the sky.[19]

And while, of course, it need not mean hostility between the young men and the old, a great change has gone on to make possible this new attitude toward life and leadership.

[18] "The Cult of Incompetence," pp. 146–148.

[19] Lodge, "Pioneers of Science." Quoted here from Burtt, "The Metaphysical Basis of Modern Physical Science," pp. 66–67.

The gist of this modern attitude may be put in a few words: There is no rightful authority save the authoritative situation. The wise man alone can be our leader, and the wise man is he who can best size up the situation, can best get at all the facts. But even he must not interpose himself between us and raw experience. His function is to point, not to order. We follow him only as he follows the facts. We follow him not because we attribute to him occult insight, but because in the distribution of labor it saves time for our specialty if we take his word for the facts in his own field of special experience.

Science, like industrialism, rests squarely upon this principle of the distribution of labor. The moment any man speaks in his own person rather than in the name of facts by which men must live, that moment he slips back to an ancient order and so far forth undermines the integrity of science. The necessity for leadership in our modern life grows out of the impossibility of any man's being omniscient. But this lack that necessitates leadership indicates the kind of leadership needed. It is of the piecemeal type. In order to know enough to lead *here*, I must choose to be relatively ignorant *there*. That means that the choice that makes me a leader *here* requires me to be a follower *there*. But I must demand of him whom I follow, even as he demands of me, that he shall not put either his prestige or his interests between me and the facts. This clearly means that in a civilized society, every man must be a follower in many fields. The only alternative to being a follower in many fields is being a follower in all fields. For he who to-day thinks to speak with authority on things-in-general remains a fool at home, and even his servants lead him.

But the peculiar virtue of a democratic society is that, recognizing that every man must be a follower in most fields, it gives each man an opportunity to be a leader also somewhere. It does this by emphasizing liberty, out of which alone can grow responsibility. It does it by emphasizing equality, which, among other things, means the right of even the humblest to live by the facts rather than by the pretensions of the proud. It does it by emphasizing such education as will fit every man to get at the facts that lure him most. And knowing that no man will live happily without truth, it develops a philosophy that so re-defines truth as to make it a mundane value of the common man rather than a transcendental goal accessible only to an intellectual or moral aristocracy.

And since democracy as a way of life does, and as a form of government ought to, aim at the greatest common good through the

development of each individual to his highest, it must be judged not by its ability to produce a few "master leaders," in deference to whom human nature abdicates its highest prerogatives, but by its ability to make every citizen a creative leader in some enterprise, however small, and at the same time a contented but critical follower of superior insight in other fields, however extended. This means of course that the crucial test of democracy is the health of science under its patronage; for if leadership grows out of a knowledge of the facts rather than out of egoistic pretensions, then it is to the laboratories and experiment stations that we must look to find those who are actually mankind's most indispensable leaders. Friends of democracy will judge France by its ability to produce not Poincaré, but Pasteur; America by its ability to produce not Washington, but Franklin. This means in the large that democracy succeeds in proportion as it discovers a form of education calculated to get at the bases of physical and social living and then makes this education accessible to all its citizens. So judged, democracy makes, heaven knows, a poor enough showing; but a showing not to be ashamed of. So conceived, it is a program yet to be adequately tried but one that faith must uphold with the desperation born of knowing that there is no humane alternative. So long, certainly, as democracy is judged by its ability to produce the kind of leadership that would subvert it, we are in a poor way to make our criticism of democracy constructive.

VII

In thus putting a supreme emphasis upon knowledge as the basis for democratic leadership, it may be objected that we are overlooking an indispensable characteristic of leadership—impartiality. This is an objection that will bear inspection, for certainly this has been the golden objective of older philosophies of leadership. Why this virtue has been so emphasized is easy to see. An all-powerful leader backed up with adequate prestige who is biased for some, and against others, would prove in the long run insufferable. How insufferable indeed such leadership has proved may be read in the unending tale of political revolutions and social rebellions that make up so much of human history. Given a ruler with irresponsible power, clearly impartiality in its use would constitute a subject's best protection. It is the least ethical demand that could be made of a ruler, and at the same time a logical expectation of one whose claim to lead completely outruns his knowledge.

Professor Krabbe has indicated in a recent book, "The Modern Idea of the State," the various expedients that aristocratic times proposed for the attainment of this supreme desideratum—a leader

without personal interests. Plato sought to guarantee impartiality in his state leaders by making their life communistic. Accepting the same arguments as are thought to justify celibacy in the Catholic priesthood, Plato denied to his guardians wives of their own, children of their own, property of their own. To deal justly with interests, to rule wisely, they needed only such detachment as would render them impartial. Over against Plato's method of destroying interests, historical absolutism has sought impartiality by elevating the leader above society, endowing him with property, honor, leisure, prestige so superior to that of the subjects as would destroy any temptation to take sides or serve selfish ends. Monarchy has thus been made to occupy "a supersocial position which enables it to intervene in the conflict of social interests with the greatest possible impartiality."

The first comment to be made upon these proposed roads to impartiality is that they are never successful. Even modern monarchs, as we all know apart from having it on Bryce's authority, "in general have chiefly relied on and favored the aristocracy who formed their courts, and have allowed the nobles to deal hardly with the humbler classes."[20] Constant discontent and not infrequent revolutions that have marked the passing of absolutism among mankind tell the silent story of leaders who diverted the rights of the many into the coffers of the few. But even if impartiality could be achieved by either route, there is no reason to think that justice could be attained only by such a negative virtue. For impartiality, to be effective, would have to rest on adequate knowledge of the interests involved.

This leads to a word regarding the third expedient noted by Krabbe to insure impartiality—a supreme emphasis upon education of the intellect. If men can be given sufficient intellectual training—so the theory runs—they can be lifted above the solicitation of passion, property and even persons, and can therefore lead wisely because impartially. A logic-machine as leader would not—it is presumed—feel the call to take sides, and democracy in its emphasis upon education has perhaps been in part vaguely moved by this hope.

It is, however, fairly clear that significant impartiality can not be attained even through this avenue. If intellect can be so divorced from interests as to be utterly neutral, it will not feel the worth of interests sufficiently to do them justice when they conflict. Such complete aloofness would certainly seek the monastery for its sphere rather than the presidency. And if "the thinking part of

[20] "Modern Democracies," II: 536.

the nation" does not attain this incapacitating neutrality, there is no guarantee, as Krabbe himself observes, that it "will not apply its thought to the advantage of those interests which concern its own class."

But to make a long story short, we know well enough that genuine impartiality is not attainable; we suspect that were it attainable, it would not be desirable. Certainly the weakness of the intellectual approach to it is indicated in Plato's admission that knowledge of the abstract ideas could not help one find his way home in the dark. Most assuredly in this complex age we no longer solicit, or accept, guidance from men who are, to use the felicitous phrase of John Stuart Mill, "unprejudiced by any knowledge of the facts." Without concrete knowledge, impartiality is worthless for purposes of leadership; and with knowledge significant impartiality is perhaps impossible. It may well be that working compromises by leaders who know, and who serve to the top of their bent, the interests they represent is the nearest approach to this ancient virtue we can now expect in political life. It may well be that democratic leadership so far as it manifests itself in legislation, for example, must in the future be not leadership, but leaderships; *blocs* are already here even in America, and it is practically certain, spite of the superficial indication of the recent election, that they are here to stay; for they mean the presence in Congress of men who really know the interests they serve and who serve them aboveboard. And those of us who see what interests have actually been served by those who professed impartiality are likely to prefer unreserved frankness to underhand betrayal.

VIII

But pointing thus toward further extension of the principle of specializiation, I do not conceal the fact that the dissipation of the grand conception of leadership inherited from authoritarianism into piecemeal leadership suggested by science gives ground for serious pause. If we are all to become specialized workers, who will make us whole again? Shall we not cease to see life steadily, when we can no longer see it whole? We can no longer fall back with Adam Smith in naïve trust that an "invisible hand" will tie back together what we have dissevered. Herbert Croly did us a real national service in pointing out some years ago that the surest way to ruin all promise of American life is to believe such a specious promise.[21] Nothing seems more certain now than that the God of our fathers, though known of old, is impotent in our hour of democratic need. He has too consistently stood with aristocrats; for

[21] "The Promise of American Life."

his leadership, like theirs, has rested upon prestige and authority. Democracy can expect no help from the celestial court as at present constituted. If democracy is not to go starkly atheistic, as many of its deepest prophets have foretold, it must invent a new God who will be sympathetic with its aims. A democratic God might prove to be the noblest work of man. But such invention is slow work and unsure. Meantime men must apparently take themselves for better or for worse.

The whole quest for social unity *via* a common goal has been tied up with a metaphysics that practically necessitated the conception of leadership that I have been calling undemocratic. The unity of medieval life illustrates this quite patly. Their goal was transcendental, and thus out of reach of natural men. Men must have leaders with knowledge, yes; but knowledge of the goal itself. This meant an esoteric knowledge that not all men could attain. Those who could attain it were in on the ground floor, and were by their good fortune constituted leaders and overseers of others. Unity thus achieved was compatible with the grossest evils, slavery for instance; for in Christ were not the bond and the free made one? Such an arrangement gave clearly enough a unity, but a unity of subordination. But no age seems to be free from such metaphysical illusions. The state absolutists from Rousseau down have substituted for this frankly transcendental goal of medievalism a relatively mundane one, the "real will." But this scheme for unification proves no more satisfactory than the other; for the "real will," being different from both the wish of the majority and even the desire of all, is so inaccessible that most men do not have it and have no way of making it their own. It must be discovered to common men by leaders who gather such dignity and power from their special knowledge of it that they feel then justified in forcing men to be free, as Rousseau put it, or, with Bosanquet, justified in coercing men to serve their own best interests, whether they like it or not.

The insistence on such procedure almost certainly means that whatever unity is achieved by mankind can not be achieved by emphasizing a common goal. We may as well face sooner or later the personal revelation that the right answer to the catechism, "What is the end of man?" is that there is none. Even individual life does not have any one goal; indeed it often has no goal at all. Life has only such ends as we set up for it ourselves; and we have never been able to set up one that anything like all people would recognize as theirs. The only way to get unity through a common goal is to coerce men into our way of thinking, and then camouflage

our immorality by declaring that we punish them for their own good. Verily the rationalizing propensity of us all was incarnated in Cotton's pious declaration that Roger Williams was not persecuted for following his conscience but for refusing to follow it in doing what he knew to be right! This technique for the attainment of social unity must then be given up for good: it is a blind alley over which should be posted, with apologies to Dante, the warning, "Renounce hope all ye who enter here."

But what can not be achieved by the traditional way of emphasizing a common goal seems to be in process of realization through the adoption of a common method of discovering and achieving our own separate goals. By substituting for specious mystic insight the common human power of observation and then by refining raw observation into scientific accuracy through laboratory experiments in natural science, through statistical methods in social science, and through rules of evidence in jurisprudence, the modern age reveals more meaningful unity than has been known among men of any previous period. The only hope for a social solidarity without coercion is continued travel down this scientific road. Whether it will lead us at last to the sociologists' heaven remains an open question. But who will not elect to join the gang that takes the venture when he sees that all other proposed routes have landed the majority of men in the theologians' hell? It may be that discordant interests finally converge as the hub of life is approached. At any rate, this hypothesis strikes me as more promising than any dependence on divine aid or on a unified goal imposed by some pretentious ones. If the fundamental interests of men do not sufficiently converge at the bottom to enable tolerance to bridge the gaps, then there is no adequate basis for social unity. If they do, only increasing knowledge can discover it and only better education can train people to organize their lives upon this insight. A dictated unity is almost as sterile as the pious brotherhood of man deduced of old from the fatherhood of God. So long as this pivotal question of the reconcilability of human interests remains open, the faith of Socrates must be the working faith of the modern man:

> That we shall be better [he said] and braver and less helpless if we think we ought to enquire, than we should have been if we indulged in the idle fancy that there was no knowing and no use in seeking to know what we do not know—that is a theme upon which I am ready to fight, in word and deed, to the utmost of my power.

Leaving unity, therefore, as a highly desirable by-product to emerge from the coalescence of interests, if deeper knowledge can show that they converge, we must turn again to make our final emphasis

upon special knowledge; for without it we can not proceed upon our democratic way.

Leadership based upon prestige and gesturing grandly, though vainly, toward impartiality was the aristocratic ideal. Leadership based upon special knowledge of the facts and flowering toward control of these facts for human ends is the democratic ideal. This newer view is an ideal that breaks the age-old monopoly on leadership and by doing so distributes far and wide the seeds of individuality. A social order in which every man leads where his knowledge justifies and follows where his ignorance compels—that is the way of life which, like the path of the just, shines more and more toward a democratic day.

RADIO TALKS ON SCIENCE[1]

SPUN LOGS

By Dr. EDWIN E. SLOSSON
SCIENCE SERVICE, WASHINGTON, D. C.

SCIENCE consists in learning from nature how to surpass nature. The chemist in particular is never content till he can do something that his teacher can't. In the field of fabrics he has made dyes more brilliant than any to be found in the three kingdoms of nature, animal, vegetable and mineral, and now he is inventing new textiles to tint with them. He beat the indigo plant on its own ground, and carried off the blue ribbon. He challenged a snail to a race, the Mediterranean mollusk that produced the "royal purple" of the ancients, and beat him, for now the chemist is making a better dye out of coal tar and making it so cheap that anybody can afford it.

Now the chemist is engaged in another competition. His rival this time is a worm. He has challenged the champion spinner of the world, one who has, for over four thousand years, held the prize for the finest and most flossy fiber, the silk worm. The worm chews up mulberry leaves and spins out through his mouth a silk thread five hundred yards long. The chemist grinds up logs of wood and spins out by means of his mechanical spinnerets a silky thread as long as he likes, for the machines run day and night and all the week long, throughout the year. And the thread the chemist makes is more uniform in size and substance, for the worm, although he was practising the spinning art thousands of years before man appeared upon the earth, has never yet learned how to produce a perfectly smooth and even filament.

Not long ago I had a chance to inspect a rayon plant, and it was fascinating to watch the process. At one end of the factory spruce logs are floated in. At the other end skeins of glossy yarn are being shipped out. The wood pulp costs about five cents a pound and the synthetic silk sells for two dollars a pound, and more than that when you buy it in the form of neckties, shirts, sweaters and stockings.

And you buy it oftener than you think you do if you prefer to patronize worms rather than men. For nearly two thirds of what

[1] Broadcast from Station WCAP, Washington, D. C., under the auspices of the National Research Council and Science Service and the direction of Mr. W. E. Tisdale.

seems to you silk comes now-a-days from chemistry instead of the cocoon. But it is not the chemist's fault that he has to disguise himself as a worm in order to market his product. It is rather the fault of the people who have a prejudice for things that are old and familiar, and are unwilling to admit that their fellowmen can make anything as good as the plants, animals or insects that have been longer in the business. The chemist would be proud to claim all his creations, but often he has to stand by while the merchant timidly introduces them to the public as "near" something or "imitation" something, or, what is worse, keeps silent and lets the buyer infer that he is getting the same old stuff instead of something new and often something better.

The dictionary is a heavy and clumsy volume and can not keep up with the swift advance of science. That is why there is no common name yet for the thing that I am talking about, these synthetic fibers made from cellulose, although they have in the last ten years come into such common use. They are often called "artificial silk," or, what is worse, "imitation silk," although they are not the same as silk and should never pretend to be. Last year most of the manufacturers agreed to adopt, and introduce through advertising, a new name, "rayon," for all products of this sort, but some of the makers, those using the acetate process, refuse to accept this general term and stick to their own trade names, such as "celanese" and "lustron."

There are four different processes of making these synthetic fibers and very curiously they are all in actual use. There are now being built in the United States factories for each of the four rival processes.

They are easy to understand in a general way, though to run them so as to turn out a uniform and satisfactory thread is a delicate and difficult operation. They all use the same fundamental material, that is, the woody fiber that the chemist calls "cellulose," though some of them get it from timber and others from linters, the short bits of cotton that stick to the seeds after the long fiber has been picked off. This cellulose is the same stuff as paper is made of.

The first step is to get the cellulose into liquid form in order to squirt it out in a fine jet as the silk worm does. But you know it is not easy to dissolve wood, cotton or paper. Water will not dissolve it, otherwise our floors would be washed away whenever they were scrubbed, or the trees whenever it rained, or our clothes whenever they are cleaned. But certain strong acids or alkalis will serve as solvents for cellulose.

The first of these solvents to be used was nitric acid with which a French nobleman, Count Hilaire de Chardonnet, made an artificial silk in 1884. When nitric acid acts upon cotton it forms what is known as "nitrocellulose" or gun-cotton, the basis of smokeless powder. This can be dissolved in a mixture of alcohol and ether, forming a thick gummy liquid that we know as "collodion" and use as new skin when our natural integument gets scratched off. After the spinning process the nitric acid is eliminated so that the threads are no longer explosive or more inflammable than the original cotton.

The second process for making synthetic silk gets the cellulose into solution by using an alkali instead of an acid, strong ammonia with copper dissolved in it.

The third process also makes use of an alkali, in this case caustic soda, with the addition of carbon bisulfide, a vile smelling liquid that is used for killing gophers. This produces an orange-colored viscous liquid, and the product is known by the trade name of viscose. Four fifths of the synthetic silk is made by this method.

The fourth process employs an acid, concentrated acetic acid, familiar to use in dilute form as vinegar.

In whatever way the cellulose is dissolved the next step is to force the solution by pressure through glass tubes in the end of which are minute perforations, like fine pinholes, from 10 to 50 of them. The liquid squirts out of these pinholes in thin streams which are coagulated into fine filaments by running into water containing something to neutralize and wash away the solvent. These filaments are then caught up by revolving reels, twisted into a thread and dried in skeins. These are packed in ten-pound bundles containing 150,000 or 300,000 yards of yarn, according to the caliber. Each spinning machine in the great room is running off the thread at the rate of forty-five yards a minute.

The final product is brought back almost to its original state, for it is a form of cellulose, except where acetic acid is used which leaves it as cellulose acetate. Rayon is chemically much the same as cotton in composition, but has the sheen of silk and takes dyes even more brilliantly, which accounts largely for its popularity with this color-loving generation. By weaving artificial and natural fibers together it is possible to dye the cloth two colors, for one dye will fix on the rayon and the other on the silk, so bringing out a design invisible in the original white weave. Novel and beautiful velvet brocades are now made by this method.

None of the synthetic fibers is as strong or elastic as natural silk. Their strength is from half to two thirds of the natural when dry,

and much less when wet. Rayon when wet takes up forty per cent. of water and swells and weakens. The wet rayon is only a half or a quarter as strong as the dry, so these artificial fabrics should be handled tenderly while wet. The original strength returns on drying. The cellulose acetate does not weaken so much on wetting, because it does not absorb so much water. Whether this is an advantage or not depends on the advertiser. The viscose people claim that viscose underwear is the best because it absorbs the sweat and so keeps the skin dry and comfortable, summer and winter. The celanese people claim that celanese underwear is the best because it does not absorb the sweat and so is chill-proof and comfortable, summer and winter. You pay your money and take your choice. In most fabrics it is found desirable to mix the rayon with wool, cotton or real silk, and so get both strength and luster.

When this business first started a few years ago, the manufacturers were so delighted at their new-found power to rival silk in luster that they went too far. They turned out satin that was too silky and slick, too glossy and glary. Now they are tempering their ambition for such illustrous fabrics, perhaps in compliance with an improvement in popular taste, and they are now working for softer tones and textures, by using finer filaments, and more of them, in a single thread. Some of the filaments now spun are more delicate than the floss of a silk cocoon. These new forms of the synthetic fiber are softer to the touch and less garish to the eye than the crude products of a few years back.

Manufacturers at first thought it necessary to make their synthetic substitutes resemble silk in sound as well as to the sight. So they fussed about to find a way of giving the new fabrics the "scroop" of the old. The "scroop" is the sound referred to by Poe in his "Raven" as:

> "The silken soft uncertain
> Rustling of each purple curtain."

In those days, when a lady had a silk petticoat she wanted everybody to know it, and since etiquette then required that petticoats, unlike children, should be heard and not seen, she had to rely upon the scroop to impress her proud possession upon the public. But after a process for putting the scroop into synthetic silk had been discovered the style changed and it is no longer considered necessary for a lady to rustle.

A new point in favor of the artificial over the natural product is the discovery that cellulose acetate is more transparent to the ultra-violet rays than wool or silk. Now these invisible ultra-violet rays

are supposed to be responsible for the beneficial effects of sunshine in stimulating the blood to resist disease, so we may expect improvement in public health if the synthetic fabrics become common wear.

Although all the four present processes of making synthetic silk were first developed in Europe, the United States now leads the world in its production and consumption. In the field of science we Americans do not distinguish ourselves on the kick-off but we beat the world in keeping the ball going when once it is put in play. The world's output of these artificial cellulose products for the present year is estimated at about 185,000,000 pounds, and American manufacturers made nearly a third of the total. We may reasonably expect that next year the United States will turn out 74,000,000 pounds, which will mean a 600 per cent. increase in the last five years.

About half of the output of rayon goes now into knit goods, especially hosiery, which is usually combined with cotton, wool or natural silk. For men's hose a mode of knitting called "plating" is commonly employed by which the inside surface of the sock is mercerized cotton and the outside is rayon, so getting the advantages of both kinds of thread.

In braid for dress trimmings the new material has almost entirely ousted natural silk.

Another use of these same cellulose synthetics, this is common but commonly unrecognized, is the thin, colorless, flexible transparent sheets, called "cellophane" or "visca," which wrap your candy or make a window in the envelope that brings you a check or bill.

This protean material seems to be a universal proxy. It can substitute for all sorts of substances. It is now appearing in the rôle of horsehair, Spanish lace, Smyrna rugs, Nottingham lace curtains and furs of various kinds. Sometime it may not be necessary to skin animals to get fur coats and collars, or to steal the silken blanket of the sleeping worm.

PSYCHOLOGICAL REACTIONS DURING DANGER

By Professor GEORGE M. STRATTON

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THERE is a growing interest in emotion. Our intellectual powers —our power to reason, to remember, to imagine, to see—used to receive our almost exclusive attention in the study of the mind. But we now know that an individual's happiness, the happiness of his

family, his effectiveness in business, his mental and physical health, may be seriously influenced by his emotions.

It has long been known that fear or anger may make it possible for a man to perform some unusual feat of strength. Fear or anger may add vigor to his muscles. But fear and anger and excitement are of far wider influence than this.

Let me illustrate this by an experience of an aviator whom I knew personally—a highly intelligent young man who served in the Aviation Corps of the United States army during the Great War. He had two accidents which were of psychological interest. But I shall refer to only one of them, an accident which occurred while he was doing that part of his training which is known as "stunts." He told me:

> Before going up on this particular day I, as usual, examined carefully my controls and found that they were working right. I then went up to a height of about 5,500 feet. . . . My first stunt was a loop, and this I went through all right and straightened out. Then I found that my elevator-control was stuck. I went up on the rise for a second loop, but instead of letting my ship whip-stall and thus run the risk of permanently damaging my controls, I kicked the rudder to the right and dropped into a tail-spin.
>
> It was at this time that a dual personality came into play. I had a rapid survey of my life, not as though I were looking at scenes of my past, but as though I were doing and living them again.
>
> Yet I was conscious at the same time of having to manage my ship. For as soon as I started down in the tail-spin I realized that I had a certain amount of time, and I went carefully over the different controls. I tried the rudder and found that it worked all right. I then moved "the stick," and its movements showed that the ailerons were working, but that the elevator was stuck. I thought that the elevator-wire might have become entangled in the leather slot where the elevator-wire goes through the covering to the outside. So I pushed the stick slowly and steadily forward to overcome such an obstruction. In shoving forward on my stick I felt the tension on my belt, which showed that the control was in some way entangled with the belt. So I reached around and found there the loose end of a wire used to support the triangle of the safety-belt, and which had been left too long and had become entangled in the wire which worked the elevator. I pulled this loose end out, and my elevator then worked perfectly, and I straightened out my ship. I was then at a height of about 1,500 feet, having fallen about 4,000 feet since the accident began.
>
> While I was falling I re-lived more events of my life than I can well enumerate. These were in orderly series, very distinct, and I can not recall that anything was out of its place.

Let me now give an experience of another person whom I know well—a trained scientist and a good observer—an experience which likewise is of great psychological interest. While sitting by the fireside in his home one morning, reading his paper, a little girl standing by the hearth gave a cry and was seen to have her dress afire. My friend jumped to his feet, recalling instantly cases of serious

personal injury by fire among his own circle of acquaintance, where there had been frightful disfigurement for life. The fearful question arose in his mind, "Is a like fate in store for Alice?"—the little girl before him. In an instant he had thought of several alternative things to do—to call for help, to carry the child to an adjoining room where there was water, to smother the flames in a rug, to tear the burning garment from her. All alternatives but this last were rejected, and for reasons; and with great violence but effectiveness, he tore the dress from her, slipping it over the child's head, and she was saved unscathed.

Another scientist whom I know was one day working in his laboratory, when he was the only one in his building. He happened, by accident, to inhale a certain gas that is a deadly poison. Instantly he thought of two means to save himself from serious injury, if not from death. He rapidly tried one of these, and it failed. He then tried the other, which also proved ineffectual; and his condition was rapidly becoming critical. He at once darted to a third alternative which he had in mind, that of reaching a telephone in an office on the floor above the one on which he was working. As he rushed out into the hall and up the stairs, he thought of several persons whom he might try to call, and rapidly made his selection of the one whom he thought would most probably be at home and within reach. The telephone number of his friend stood out, he says, clear, and inches high in his mind's eye as he ran up the stairs. He was just able to gasp a few words of explanation to this friend when be became unconscious. Assistance was hurried to him, and after long and hard labor he was restored to consciousness and his life was saved.

Some of you doubtless have had interesting experiences during a sudden crisis. Whether yours have been like those I have given or very different, I should be glad to have you send me in writing exactly and fully what happened in your case.

For all these experiences help us to understand what is done for us by certain forms of emotion. Sometimes a strong emotion may disturb the behavior of mind and body and make it ineffective. Deep sorrow or disappointment, and in some cases intense fear, may have this effect. It is notorious that in excitement absurd things may be done. When Morgan's men were making their famous raid into the North during the Civil War, their conduct at certain moments was that of men beside themselves. They would rush into some country-store and, in a whirl of greed, seize anything at hand. They would stuff their pockets with horn buttons, start off to southern climes with a string of skates, or with a chafing-dish on pommel, encumbrances only to be thrown to the roadside after some miles of gallop. They behaved, it is said, like boys raiding an orchard.

After the conflagration in Berkeley, California, a year and more ago, I was looking over some of the salvaged possessions which had been brought to a fire-proof building of the university. There, beside a fine mahogany grandfather clock, well worth saving, was a pan half-full of baked apples! So a man's golf or his billiards might easily be upset for the time by an insult offered him, or by the sudden news of some great loss to his business.

But this is not the whole truth, for it is evident that our aviator, during his period of danger, was excited, but he did not lose his head nor lose the full control of his body. He was able to try out his rudder, and his ailerons and his elevator, to see which of them was out of order. He disentangled the wire from his belt, which had become caught in the wire running to his elevator. He was then skillful enough to take his ship out of its tail-spin and straighten it out while there was still some distance between him and the ground. In a like manner my two scientist friends each retained his skilled movements, of standing, grasping or speaking, and so on. And in general, the man who is joyous still knows how to whistle or sing or walk with a sprightly step; and the angry man does not forget the use of language, especially that of vituperation. He is able to walk toward his opponent and threaten him with fist and voice. In some instances emotion makes a man use better what skill he has. On the day after a deep disappointment, in one case I know, a man played a better game of golf than he had ever played before. Often there is a greater variety of muscular movements which are at the disposal of the man who is in an emotional state than of the man who is wholly unexcited. The excited man finds himself able to pass from one kind of act over into another with greater readiness. The changes can be made more rapidly, and there are more things which lie ready for him to do.

The effect upon the muscles, however, is not all. There is also a decided effect upon the intellectual powers.

In the first place there is, in excitement, a repression of ideas and acts which are inappropriate; there is a pushing aside of everything mental which offers no help to meet the crisis in hand. The aviator had something like a series of dreams which ran along beside his practical behavior. Various thoughts that could not help him in his danger were forced aside and became an active system of their own. In a way, this is what happens when soldiers who are wounded do not until afterwards feel any pain; or when David Livingstone in Africa was seized by a lion and his shoulder was crunched and crushed. The shock, he tells us, produced in him only a sort of dreaminess, without pain and without terror, an effect which he compares with that of chloroform.

Besides this setting aside of useless ideas and impressions, there is a speeding-up of the thinking which is useful. My aviator, my two scientists, in their times of danger, were able to think far more quickly than was usual. Each thought with amazing rapidity. But what is more important, each was able to think with remarkable fertility and effectiveness to meet the particular crisis in which he found himself. His judgment worked clearly. The aviator, the two scientists, had to think up and consider a number of alternatives in order to discover how best to meet the trouble each was in. Just as his hands were not paralyzed or clumsy, so his thinking was not paralyzed or clumsy.

So the man in the presence of someone who has injured him is apt to think of many things that he might do or say to injure his opponent in return. The young man in love fairly blossoms with ideas as to ways in which he may express his affection or gain success over a rival. Turgeniev, the Russian writer, when asked in his latter years why he was not writing as much as before, said that he was too old to be in love, and that he had found that unless he were a little in love he could not write.

Thus certain kinds of emotion or certain phases of all emotion render us valuable service. For when an individual is stirred he finds himself for the time being on a new level of behavior, both of mind and body, and is able to meet his crisis with a more complete array of his powers and with a better organization of them. And let me repeat that these powers are not those of his muscles only but are of his entire personality, both of body and of mind.

THE AWAKENING IN SCIENCE

By Dr. H. E. HOWE
WASHINGTON, D. C.

THE desire of the modern scientist to have the non-technical public acquainted with his work is one of the striking differences between to-day and yesterday. In the earliest times scientists encouraged the public in the belief that their work was one of mystery and legerdemain. This gave rise to the odd codes and symbols of the alchemists, to the use of Latin in medicine and to the adoption of symbols and formulas in pharmacy, well calculated to keep secret from the public the real composition of the remedies prescribed. Nowadays, it is true, scientists use a sort of shorthand, but no serious effort has been made until lately to have the public appreciate that modern formulas, symbols and abbreviations are used for

convenience only and are really an easily understood system of abbreviation rather than an undecipherable code.

One of the factors influencing this change in the attitude of the scientist is the realization that in many respects science has progressed beyond the industrial application of some of its newly discovered facts and that the arts have lagged behind until the public fails to appreciate the significance of scientific work. The public generally fails to support fundamental research on an adequate scale, therefore, not so much from a lack of sympathy as from a lack of understanding of its significance.

The chemists were among the first to realize the necessity of encouraging the general public to become better read in science, to appreciate the cultural value of its study and to learn that many stories of accomplishments in the field of chemistry were more engaging than fiction. Their purpose is not to encourage large numbers to become chemists, but to induce still greater numbers to know a little of the relations of science to our everyday affairs. The ever-increasing numbers in our high schools suggested the possibility of obtaining a greater familiarity on the part of the public with science by starting with these students. Consequently, the American Chemical Society has been enabled through the beneficence of Mr. and Mrs. Francis P. Garvan, of New York, to offer substantial prizes for the best essay on each of six chosen subjects, these prizes being available for every state, the District of Columbia and the extra-territorial possessions of the United States, taken as a unit. These subjects are: "The relation of chemistry to health and disease," "The relation of chemistry to the enrichment of life," "The relation of chemistry to agriculture or forestry," "The relation of chemistry to national defense," "The relation of chemistry to the home" and "The relation of chemistry to the development of an industry or a resource of the United States." The winners in these states compete for four-year scholarships at Yale or Vassar, which are awarded as national prizes in these same groups. In the 1923–24 contest the winners were located as follows: Centralia, Washington; Santa Rosa, California; Hartford, Connecticut; Commerce, Georgia; Dallas, Texas, and Phoenix, Arizona.

Furthermore, in the 1924–25 contest large cash prizes are offered for the best essays on the same subjects prepared by undergraduates in our colleges and universities. Thousands of sets of books have been distributed gratis to high schools, colleges, libraries and individuals interested in education in connection with this effort, and a new volume has been especially prepared, dealing with instances of chemistry in the service of industries. Complete information regarding the current contest may be had by addressing the

secretary of the Prize Essay Contest, at 85 Beaver Street, New York City.

Another conspicuous effort to give authentic information to the public is the News Service of the American Chemical Society, which distributes without charge stories of the progress of science. That the public appreciates this information and prefers it to the sensational stories at one time circulated is evidenced by the fact that the space devoted to such scientific announcements in the daily press has increased twenty-five fold in the last six years.

Still another successful effort is that of Science Service, an organization controlled by the National Academy of Science, the National Research Council and the American Association for the Advancement of Science. Science Service, endowed in order that a part of its overhead may be assured, prepares on regular schedules popular but authentic stories of new discoveries in all the fields of natural science and distributes them to newspapers throughout the country.

The public has found science so interesting that the established publishers are providing a great number of books written in non-technical language covering most of the natural sciences. There are still too few of these informing volumes, but with the growth in popular demand we may confidently expect our best scientific authors to engage in the preparation of accounts of their work, written from the standpoint of the general reader.

In many parts of the country broadcasting stations, appreciating the educational value of science stories, are making it possible for university and other groups to go on the air with short accounts of what has been done or is in progress in scientific laboratories and industries founded upon science to improve public welfare. The same universities are even giving specified courses in scientific instruction by means of the radio.

We may look forward to a not far distant time when unfamiliarity with the progress of science will be looked upon as an evident fault in education and training, even as we now look upon a lack of acquaintance with the classics, with history or current events. It is fortunate that so many agencies are at work to assist the non-technical reader and the general public, and you are missing something worth while if you fail to make the most of the opportunity.

The opportunity to take and hold the lead in industry as well as in science has not been overlooked in America, where to-day a larger sum of money is being devoted to research than at any period in our history. Indeed, it is doubtful whether any nation is expending a greater amount of time, effort and money in scientific pursuits than is the United States. We commonly think of scientific research

as an activity pursued principally in the laboratories of educational institutions and in the various bureaus of our federal and state government departments. It is true that most of our fundamental work is carried on under such auspices, but it is noteworthy that in recent years great industrial establishments have seen the necessity of pursuing such work on their own account in order that their material progress may not be arrested. Research has also been found to pay such industries in more indirect ways, as, for example, the fact that a better grade of employees is attracted to an institution where the scientific spirit prevails, that the business man himself finds a new interest in problems open only to scientific attack, and that there is a feeling of confidence in the future where research is one of the potent factors in business not to be found in those industries relying solely upon past experiences.

There are approximately 250 educational institutions in the United States in which research in physics and chemistry is being carried on. There are somewhat over a thousand men and women actively engaged in this work and well over a million dollars devoted in these laboratories to research activities. Accurate statistics regarding industries are not available, but it is certain that a sum approximating twenty million dollars is spent in an average year upon research, control and developmental work involving physics and chemistry, to which should be added a sum of several hundred thousand dollars for work spent in the biological sciences, not including medicine. The fields of biology, particularly biological chemistry and several aspects of the medical sciences, offer such great opportunities for the well-trained men in research that a constantly increasing sum of money is being judiciously spent in such endeavors, but figures are not available. Add to this sums spent in the governmental laboratories—federal, state and municipal—and we shall find a very large sum of money being invested annually in the search for truth to be ultimately applied to the welfare of the nation and of the race. The last decade has seen an increase of approximately 30 per cent. in the appropriations in America for research activities, and notwithstanding this increase there is an ever-present need for large additional sums for the support of scientific work.

Thanks to unparalleled natural resources, we still seem able to live largely upon our capital rather than our income. But far-sighted men and women are beginning to appreciate the necessity for not only confining ourselves to the income from our capital, but actually laying aside a surplus for the future. This means that we must learn to make better use of all sorts of natural resources, that we must develop methods for utilizing low grade materials,

that there must be greater progress in the synthesis of products that the laboratory may supplement the diminishing supplies of substances heretofore found only in nature and that we must continue our efforts in search of the ultimate structure of matter to the end that with such information our manufacturers in all fields may proceed with the greatest assurance of obtaining the utmost in yield and quality.

The fact that applied science, which every one can surely appreciate, always depends upon facts won through abstruse research explains the necessity for the popularization of science. At present the public is not sufficiently informed of this relationship to support the research worker to an extent which makes it possible for him to lay the foundations for processes and devices which in turn provide us with safer, longer and more enjoyable living. Those who work in pure science often seem to the public to be far removed from everyday problems, but you, who are the public, need consider but for a moment to realize what our present-day civilization owes to research in the fundamental sciences.

THE ELECTRICITY OF THE AIR

By Dr. S. J. MAUCHLY

DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON

ABOUT one hundred and seventy-five years have elapsed since Benjamin Franklin proved by his famous kite experiment that lightning is identical with the electricity of our laboratories. From that time forward well into the present century, the subject I have chosen would have suggested, to most people, a discourse on lightning or thunder-storm electricity. But to-day, with a radio receiving set in nearly every home, we have all become more or less familiar with the fact that radio transmission and reception are in large measure dependent upon the electric conditions of the air even during the fairest of weather. Time will not permit me to attempt a discussion of all the electrical phenomena of the air, and I shall, therefore, confine my remarks to the silent and unseen electrical phenomena which are continually taking place in the air surrounding us, while we work or play or sleep. I shall endeavor to give briefly some of the most interesting and important of the known facts regarding this so-called "fair-weather electricity" and occasionally a bit of theory regarding them.

For example, in the space surrounding the earth and occupied by the air there is an electric condition called potential which some-

what resembles the pressure in a water main. However, this force differs from ordinary pressures in water or air in that it affects only bodies which are electrically charged; that is, it acts as a motion-producing force on particles of air, dust, drops of water, etc., which are electrified but does not affect those which are neutral or uncharged. Technically this is referred to as the earth's electric field, and the volt with which every one is more or less familiar is the unit used in measuring its strength or intensity. But the air-potential normally increases with height above ground, and it is, therefore, customary to refer to the earth's field as being so many volts per meter or volts per foot to show the amount of change in potential for a meter, or for a foot, of change in height. For our present purpose, however, we shall in most cases be concerned only with the potential at a given point.

The strength of the earth's electric field under average fair-weather conditions is such that the electric potential of the air at the height of a man's head is usually several hundred volts greater than it is at the ground beneath his feet. Or, in other words, out in the open, away from buildings and trees, the difference in electrical potential between the ground and a point five feet above ground is usually somewhat greater than the difference of potential between the lead wires of the ordinary house-lighting circuit. Combining this experimental result with well-established electrical theory leads us to the startling conclusion that the entire earth is electrically charged to a potential of many millions of volts. This at once raises a question as to why we are not subject to injury or discomfort as a result of living in such a strong electric field. I will return to this point again later, but for the present I may say that, electrically speaking, our bodies really form a part of the earth and our position is somewhat similar in this respect to that of birds sitting without harm upon a high-tension electric wire. Our observations also show that at a distance of say ten feet above ground the potential of the air is twice as great as at the five-foot height, etc., and that a free balloon at an elevation of a mile may be at a potential fifty thousand or more volts greater than at the ground.

At many observatories in various parts of the world the electric potential of the air is continuously recorded by automatic instruments. Three such observatories are maintained by the Carnegie Institution of Washington, one being in the District of Columbia, another at Watheroo, on the plains of Western Australia, and a third at Huancayo, in the Peruvian Andes. Records so obtained show, in all cases, that the electric potential of the air where the instrument is placed changes continuously throughout the day and

that the daily change, at any given locality and time of year, is very similar from day to day. In some regions the daily change is much the same throughout the year, but in many localities the average daily change during the winter season differs very much from the average daily change during the summer.

The Department of Terrestrial Magnetism of the Carnegie Institution of Washington is making careful and extensive studies of the changes in the earth's field during the day, during the year and from year to year, based on continuous air-potential observations in all parts of the world. One of the most striking results thus far obtained is that the chief daily maximum or high point tends to occur everywhere at approximately the same instant. Thus, for example, the highest potential occurs shortly before noon in Washington, in the late afternoon or evening in most parts of Europe, and between midnight and morning in Western Australia and Eastern Asia.

It is further found that, at most stations in both the northern and southern hemispheres, the average value of the atmospheric potential for a given place and at a given height above ground is greater during the months from October to March, inclusive, than during the remainder of the year, although there are several regions where the reverse seems to be true.

The origin of the electric charge on the earth and of the resulting electric field is not known. And, as if to add to the interest and to the difficulty of finding a suitable explanation, it appears that there are gradual changes from year to year in the atmospheric potential which are in close relation with observed sunspot changes. Thus, in trying to explain the existence and variability of the earth's electric field we must take into account not only the entire earth but also conditions on the sun.

Another matter of great importance in atmospheric electricity is the electric conductivity of the air or its ability to carry an electric current. For, although the air is one of the best-known insulators, it is far from being a perfect insulator. As is well known, air consists almost entirely of small particles, called molecules, of nitrogen and oxygen. While most of these molecules are electrically neutral, there are always a few—only a small fraction of a per cent. of the total number—which are charged, some positively and some negatively. Those positively charged are called positive ions and those negatively charged negative ions. Now positive and negative ions attract each other, and whenever two oppositely charged ions meet their charges neutralize and they again become ordinary uncharged air particles. Thus, the ions of the air are constantly disappearing, and the air would soon be in a neutral or un-ionized state

unless a new supply of ions was constantly available. However, new ions are being formed at such a rate that a cubic centimeter of air under ordinary conditions usually contains about one thousand free or uncombined positive ions and, roughly, the same number of free negative ions, that is about sixteen thousand of each kind to the cubic inch. The process by which these ions or charged particles are produced is somewhat too complex for description at this time. In brief, it may be said that the small amounts of radium and thorium naturally present in the air and the direct action of sunlight are largely responsible for their continued formation. From observations over the oceans and in balloons it appears that a so-called "penetrating radiation" may also be one of the important causes of the ionization of the air, although the nature of this radiation is not well understood.

Under the action of the earth's electric field the positive ions of the air normally travel toward the ground and the negative ions in the opposite direction at a rate of nearly an inch per second. Consequently, under normal conditions, there is everywhere an electric current passing from the air into the earth. I have spoken in terms of thousands and millions of volts and must, therefore, hasten to prevent the impression that our lives may be endangered by the current thus produced. In fact, if the entire human race were collected out in the open at one time the total flow of current from the air to the ground through the bodies of the assembled multitude would be less than that required to operate an ordinary reading lamp. Nevertheless, small as this current is at any one place, its total amount over the entire earth is by no means negligible and is estimated to be at least one thousand amperes. Moreover, although the earth is, as already stated, charged to a potential of many millions of volts, 90 per cent. of its charge would be neutralized within ten minutes by this air-to-earth current if there were no source of replenishment.

Many investigators believe that the sun is the source of this replenishment, and various experiments have been made to test this point. However, no proof has yet been found that electricity from the sun actually gets down into the earth. It has been suggested also that lightning discharges may be the source of replenishment, since such discharges, while comparatively infrequent in a given locality, are probably taking place almost continuously if we consider the whole world. However, some lightning discharges bring positive electricity to the earth, while others bring negative, and it has not yet been shown that the negative discharges are in excess of the positive by an amount sufficient to counteract the constant downward current of one thousand or more amperes.

All our direct knowledge of the ionization of the air is necessarily limited to those parts of the atmosphere which have been reached by balloons. However, from purely theoretical reasoning, investigators have long believed the air at some very high level to be highly ionized and to have an electrical conductivity enormously greater than that of the air in which we live. Observations in balloons and on high mountains do, indeed, show that the air gradually becomes a better conductor of electricity as higher levels are reached.

Most radio investigators now believe that a knowledge of the electric conditions of the upper air is of the utmost importance in matters concerned with the improvement of radio communication. Unfortunately, we have at present no observational means for directly exploring the upper air at the heights which are here involved. However, there are promising indications that valuable information concerning the upper regions of the air may soon be obtained by the correlation of indirect evidence. For example, by the use of selected radio wave transmissions in particular directions, at particular times and on particular frequencies, the radio engineer is now able to obtain much valuable information regarding the electrical conditions at elevations far beyond the reach of direct attack by the student of atmospheric electricity. Thus, the correlation of effort between workers interested primarily in the study of atmospheric electricity and those whose chief interest lies in the field of radio communication will certainly contribute to the solution of outstanding problems of common interest.

BLASTING A NEW FACE ON NATURE

By Dr. CHARLES E. MUNROE
NATIONAL RESEARCH COUNCIL

DURING a recent visit to our splendid Military Academy at West Point, New York, my hosts, among other attentions, motored me over the recently opened Storm King Road which rounds the "Klinkenberg" or "Echo Mount," high up on its steep side and leads on to that country of legend and mystery made famous by Washington Irving in Rip Van Winkle and other tales.

With the rapid multiplication of automobiles, propelled by the explosion of explosive mixtures within their cylinders, congestion on all highways has become marked; especially on those in and about great centers of population. In the valley of the Hudson there was but a single highway, located on its eastern bank, leading to

Albany and at times automobiles, notwithstanding their capacity for speed, have been compelled to move at, practically, a snail's pace. It was obvious that a highway on the west shore would relieve this congestion, but there stood the Klinkenberg, one of the highest peaks of the group, like a "storm king" at the northern "Gate to the Highlands." A mass of rock, many hundred feet in height, rising abruptly from the bank of the river, and bordered with deep ravines, such as Big Gully, it barred the way. By means of high explosives, it was a comparatively simple thing to blast out the face of this mount so as to provide a ledge for the roadway, rock for building the parapet and retaining walls, and material with which to fill the ravines to be crossed.

By the aid of explosives, roads, many of great length and passing through rugged mountainous regions, have been and are being built all over our country, giving easy access to all parts of it, and opening large areas of land to the occupancy and use of our rapidly growing population.

Among the more important of these roads, one might name the Columbia River Highway, four hundred miles in length, passing through the Cascade Range of Mountains and disclosing most magnificent scenery; the Pacific Highway, now paved from the Canadian to the Mexican borders, and the Lincoln and Lee Highways, which, when completed, will join the Atlantic with the Pacific. The Needles Highway of South Dakota penetrates the very heart of the hills and opens to public view fourteen miles of unusual needle-like granite formation of unforgettable beauty—a scenic paradise. The federal government is distributing many million pounds of surplus war explosives for use in building roads in each of the states.

It was in other avenues of transportation that the value of explosives was earliest recognized. The first application of gunpowder, of importance in this field, was probably at Malpas, France, during 1670–1681, in the construction of a tunnel 510 feet long, on the Languedoc Canal. The latest, and by far the greatest, example in this field is the Panama Canal, where explosives were used on the most extensive scale ever known in canal construction.

With the invention of the locomotive by George Stephenson and the development of transportation by rail the advantage of easy grades and direct routes was emphasized. From the beginning railroad builders have sought to remove obstacles and not to evade them. Hence from the beginning they have employed explosives with which to cut and fill, or, where the overburden was large, to pierce. The first railroad tunnel in the United States (driven in 1831 to 1838, on the Alleghany and Portage Railroad in Pennsylvania) was 901 feet in length. During 1854–1876, the Hoosac Tunnel, four and

one quarter miles in length, was driven through Hoosac Mountain, Massachusetts. Dynamite was extensively used in this work and a factory to supply the nitroglycerin was built at North Adams. During 1857 to 1872, a tunnel, 7.6 miles long, was driven through Mt. Cenis, and since then other tunnels have pierced the Alps. To-day work is in progress on the Moffat Tunnel, 6.09 miles in length, to pierce the Continental Divide. It is to replace the twenty-three-mile route by which the Denver and Salt Lake Railroad now surmounts the Rockies, reduce the lift on all that is moved by 2,400 feet and eliminate the tremendous expense and numerous delays due to the heavy snowfalls encountered at this altitude. It is estimated that over 3,000,000 pounds of high explosives and 325,000 detonators will be required in carrying out this project.

The longest of these transportation tunnels is short when compared with the thirty-one miles' length of the Croton Aqueduct, or the Shandakin Tunnel in New York's more modern system, 18.1 miles long, and said to be the world's longest continuous tunnel. In irrigation and water supply projects explosives play an essential part, not only in the driving of tunnels and general excavation work in difficult earth and rock formations, but also in the building of dams. For it is by their use the rock for the base and the materials for the cement with which the concrete is compounded is blasted from the quarries and comminuted to workable size. At certain localities it has been proved feasible, by means of explosives, to blast large masses of material from the adjacent banks with which to dam the stream.

These dams, like the Roosevelt and Wilson dams, cause large areas of country to be submerged and artificial lakes to be formed. Through the damming of the streams in the Catskills, to form the Ashokan and the Schoharie reservoirs, storage for 128,000,000,000 gallons of water has been secured in the first, and for 20,000,000,000 gallons in the second mentioned reservoir. By such construction in inhabited regions large areas of farm lands, long occupied as homes, and even villages disappear.

Ocean transportation also makes its demand on explosives, especially in the removal of obstructions which menace the safety of vessels, and this demand becomes the more urgent with the increase in size, draft and speed of vessels. In the latter part of 1885 the residents of New York City were thrown into a state of consternation by learning that Flood Rock at Hell Gate in New York Harbor had been mined, charged with some 289,000 pounds of rack-a-rock and dynamite, and was to be blown up, and all manner of predictions as to the damage that would result, even to the entire destruction of the city, were made. The mine was fired on October 10,

1885, by little Mary Newton, daughter of the chief of engineers, United States Army, but, beyond the disintegration of Flood Rock, the production of a fountain of water, over the area of the rock, which rose in some parts to a height of 160 feet, and a small tidal wave, no other obvious effects resulted. It did, however, give rise to an earth wave which was recorded as far away as Albany, New York, to the north, and Cambridge, Massachusetts, to the east. Through observations on big blasts like this, Mallet, Milne, Omri and other experts have learned much as to the methods of transmission and behavior of earthquake waves.

The 289,000-pound charge used in demolishing Flood Rock was then the largest charge of explosives ever fired in a single blast, and it remained unchallenged until during the Great War the Germans started, just after the first battle of Ypres, the practice of mining the trenches. The British organized a special corps to meet this form of attack, and in June, 1916, some 227 mines were sprung on the British front. This form of warfare culminated on June 7, 1917, when the British sprung a mine at Messines Ridge charged with 933,200 pounds of high explosives. This was a tremendous amount, but it was distributed in twenty charges, over a front of approximately 14,500 yards in length and the explosions occupied approximately thirty seconds, so it is hardly on "all fours" with Flood Rock. Referring in his "Memoirs" to this blast, General Ludendorff says: "The moral effect of these explosions was simply staggering."

More spectacular and hazardous was the blowing off of the top of the Col di Lana, a cone-shaped peak in the Dolomite Alps, and a pestiferous stronghold of the Austrian army (as planned and executed by Prince Gelasio Caetani, Italian ambassador to the United States, and his associates), with some five tons of explosive gelatine, by which the Italians captured that front.

The United States is perhaps the largest manufacturer and user of explosives. The Bureau of Mines reports that 529,727,859 pounds were used in this country last year. Also this is the country of large blasts. For years charges of one hundred thousand pounds have not been infrequent. On February 16 last, 301,200 pounds were fired in the Lakeside quarry of the Southern Pacific Railroad, forty-seven miles west of Ogden, Utah. On April 27, last, 364,000 pounds of dynamite were fired at the quarry of the Blue Diamond Materials Co., Corona, California. This was probably the largest movement in real estate in California since the earthquake and this charge of explosives now holds the world's record.

INSECTS AND HUMAN WELFARE

By Dr. E. P. FELT

STATE ENTOMOLOGIST OF NEW YORK

INSECTS are to be found almost everywhere. Under certain conditions they cause serious losses to man. They not only destroy crops and other property, but function as the active agents in spreading death in some of its most horrible forms.

The vast numbers of insects, the great variations in species, the ready adaptations to environments, the enormous prolificacy are all factors which place insects among the most dangerous enemies of man. There are some who profess to see in insects a real menace to the future welfare and development of the human race. It is certainly a question which should receive careful consideration and one can not be too cautious as to the conclusions drawn from available facts.

In passing, it may be well to recognize the fact that many insects are decidedly beneficial, directly or indirectly. The flower-visiting bees and flies in particular make possible the thorough fertilization of fruit blossoms and in that way alone add greatly to the material prosperity of man. The honey and the wax of the honey bee are well known and have been prized from ancient times. The silkworm, the cochineal insect and the lac insect all make contributions to our well-being. There are, in addition, long series of predaceous and parasitic insects which, by destroying their associates, keep potentially injurious species from becoming destructive. The balance of nature in relation to insects is so delicately adjusted that under normal conditions only a very few species become sufficiently numerous as to be destructive, in spite of the fact that a very large proportion of the myriad species depend for sustenance directly upon vegetation.

It is well known that insects levy a high tax, as it were, upon the products of farm and forest, the loss by no means ceasing when the crops are harvested and the trees manufactured into lumber and wood products. It is easy to point to the enormous losses caused by the Hessian fly, the cotton worm and the boll weevil of the south, the spruce bud worm, the bark beetles of the genus Dendroctonus in the Appalachian and western forests and the more recently introduced gipsy moth and the European corn borer of the northeastern United States. All these and a number of other insects cause or have caused enormous losses to our products.

The outstanding depredations have resulted from combinations unusually favorable to the development of insects. The Hessian fly, for example, finds ideal conditions in the extensive wheat fields of this country, provided sowing is early enough to permit an abundant infestation in the fall. The extensive cotton fields of the south afford a paradise for the cotton worm and the boll weevil. The large areas of mature or nearly mature timber in our wooded sections have met, in a most admirable manner, the requirements of certain bark beetles. The spruce bud worm, reveling in the abundance of balsam in our northern forests, periodically turns to the less acceptable though much more valuable spruce and then causes tremendous losses. The gipsy moth and the European corn borer have found in this country comparative freedom from insect parasites and a superabundance of plants adapted to their needs.

It is significant that over half of our more injurious species have been introduced from abroad. The establishment of species from other countries is probably still going on in spite of the fact that quarantines have never been more numerous or better administered. Furthermore, there are presumably in this country at the present time a number of recently introduced insects which, in the course of ten to twenty years, may assume the status of major pests. That is, they are existing at the present time in such small numbers as to escape notice. The gipsy moth, for example, existed in New England for some twenty years before it became sufficiently abundant to attract attention. Generally speaking, in the case of introduced pests, we may expect a period of acclimatization and adaptation accompanied by little or no injury, then there may be enormous multiplication and very serious losses extending over a series of years and this in turn be followed by a gradual decrease in the numbers of the pest and the establishment of what might be considered the normal for this country.

These introduced species disturb, to a greater or less extent, the relations existing between other insects and their food plants, though in time this may be corrected, to a very considerable extent at least, either through the development of native parasites or the introduction of such forms from the native home of the pest. Present conditions in this country are favorable for the appearance of new pests with accompanying losses, yet these latter will presumably be offset, to some extent, by a decrease in the numbers and ravages of injurious species now at the height of their destructiveness.

A change in habits or distribution in a country is also responsible for the development of injurious insects. The Colorado potato

beetle, originally living upon the bull thistle in the Rocky Mountain region, found the cultivated potato much more to its liking and has gradually established itself throughout most of the United States. The Mexican bean beetle of the southwest appears to be following in the footsteps of the Colorado potato beetle, though it has spread more rapidly and is seriously injurious to several important crops.

The extensive depredations alluded to above are the logical outcome of changes in the flora, due to the extensive planting of crops or the allowing of trees over large areas to reach a mature and most attractive condition for certain borers. The assumption that such ravages are likely to increase in the future is based upon a presumed continuance and accentuation of these conditions. This is hardly creditable to the discernment and foresight of those responsible for the development of our agriculture and forestry. Nature is teaching in a most practical way, namely, through economic losses. It is fair to assume that the pupils, the men of to-day and to-morrow, are learning these lessons and gradually bringing about a modification which will result in less extensive losses from the work of destructive insects. In the case of field crops, this may sometimes be accomplished by modifications in agricultural practices or the growing of more resistant or less attractive varieties. The adoption of direct control measures is entirely feasible for the valuable fruits, a practice which has become very general in the last generation, and is now becoming increasingly prevalent in the case of ornamental trees of our streets, parks and more pretentious estates. Material progress is to be noted along these lines and in the course of another generation or two we may look for marked benefits as a result of systematically avoiding conditions favorable to the development of insect pests.

There is another factor which should be taken into consideration. The inevitable increase in the population of this country means a higher, more intensive type of agriculture and a gradual though inevitable reduction in the extended areas devoted to special crops. This results, irrespective of intelligent efforts to check insect depredations, in the gradual development of conditions less favorable for an abnormal multiplication of insects through a diversified agriculture with its smaller cotton and corn fields and more carefully managed forests.

The comparatively recent discovery of the part played by insects in the dissemination of disease has given ground for serious apprehensions and in some cases, at least, individuals have failed to realize that death by yellow fever, typhus or typhoid is no more

horrible when the agent is known than before. They have failed to recognize the fact that with knowledge there comes, almost inevitably, a more general adoption of preventive measures. These discoveries, while making certain insects more abhorrent, really decrease the probabilities of wholesale loss of life through such agencies. It is impossible to believe that, under present conditions, wholesale decimation may result from insect-borne diseases. The black death of the middle ages, with its paralyzing loss of life, occurred at a time when the louse dwelt with royalty and was by no means a stranger to the common herd. The louse still exists. During the great war, the stage was set for a tremendous outbreak of typhus and other deadly infections carried by this pest. The signs of the times were read correctly and the leaders of men turned their efforts, in part, from slaughtering each other to fighting a common foe. They won, but not before thousands of lives had been lost in certain areas. Much the same might be written of yellow fever, one of the most dreaded and deadly scourges in the early years of this country.

The diseases mentioned still exist, the insects are still to be found, but wide-spread epidemics are impossible under present-day conditions, because our medical men have learned that these insects without the infections are practically harmless. Well-directed efforts toward keeping the numbers of these disease carriers down to a minimum and the safeguarding of the remainder from infection have resulted in liberating mankind from a number of most deadly scourges and this under conditions which were far from favorable in many cases.

There should be no minimizing of the destructive and dangerous rôle played by insects. On the other hand, we should take account of what has been accomplished and realize that the destiny of the human race will be decided, in large measure at least, by the energy and intelligence brought to bear upon the numerous and exceedingly important problems forced upon us by the myriads of insects found at every turn. We should not forget that, although insect increase is theoretically illimitable, practically speaking, there are bounds which even they can not pass. There is a balance or an equilibrium in nature which is found throughout the entire sequence of animal and plant life and whenever this balance is disturbed there is likely to be a great increase in the activities of some agency, accompanied by a trend back to normal. Practically speaking, an insect or a plant disease can not exterminate its host, though under certain conditions there may be a close approach thereto over limited, though possibly extensive areas. The plant-

feeding insects are subject to attack by insect parasites, numerous other natural enemies and in not a few cases fall victims to adverse climatic or other physical conditions. The same is true in a general way of those which disseminate disease. Widespread fluctuations are to be expected and, viewed from the standpoint of the individual, limited to a restricted area, these may be catastrophic in extent. In the broader sense, however, these are only billows upon the sea of life. They can not rise beyond a certain level and inevitably must drop to or below a line which may be designated as the mean of equilibrium.

SHADOW BANDS

By Professor HARLAN T. STETSON
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FEW phenomena outside the solar corona itself probably excited more curiosity at the eclipse of the sun of January 24, 1925, than the so-called shadow bands.

Many observers who watched for the onrushing shadow of the moon and failed to glimpse it because of a poor vantage point for observation were fully rewarded with the extraordinary display of shadow band phenomena. This curious display of shimmering ripples of light and shade to be observed shortly before and immediately following a total eclipse was seen and described as early as 1820 by Goldschmidt and has been identified by later observers as more or less parallel lines of shadowy waves in rapid motion across the landscape. At some eclipses these alternate bands of light and shade have appeared to be narrow and at other times broad. The distance apart between the bands has likewise been observed to vary with different eclipses and in different localities. The velocity of these moving bands moreover varies greatly in speed and direction and has been thought to be dependent upon the wind. On certain occasions at total eclipses no shadow bands whatever have been seen either before or after totality. The freakish character of the will-of-the-wisp phenomenon has long been thought to be due to atmospheric disturbances. This interpretation seems to be substantiated by the additional fact that shadow bands at eclipses do not appear to differ greatly in character from the shadow bands which may be observed from a narrow or point source of light shining through a layer of air which is agitated by convection current rising from a heated body between the illuminated source and a light background. The bands as displayed at the last eclipse were quite generally seen and were especially conspicuous on account of the fresh layer of snow which blanketed the eastern states on the morning of the eclipse. Furthermore, the anticyclonic character of the weather was particularly favorable for a turbulent condition of the atmosphere so favorable to the appearance of these bands.

For one to fully appreciate the fairly simple condition under which these bands arise it is only necessary to watch the brighter stars on any night, especially on one following a violent change in meteorological conditions and observe the incessant scintillation or twinkling which takes place as the tiny pencil of light from the restricted source is wafted about hither and yon while traversing the

perturbed ocean of our own atmosphere. Were the light from a star sufficiently brilliant, these irregular flutterings could readily be seen projected on any white surface. Were the star a narrow slit in place of a point source these patches of light and shade would be drawn out into roughly parallel bands.

When, therefore, with the approach of totality the sun's brilliant disk is narrowed down to a slender crescent subtending but a few minutes of arc, we have the stage set for shadow bands of sufficient intensity to be seen on any light surface, such as pavements or the walls of buildings. Many explanations of shadow bands have been written, and artificial shadow bands produced by laboratory experiments. More than forty years ago the bands were produced artificially and described by W. H. Pickering,[1] the apparatus concerned being a searchlight set on the roof of the Physical Laboratory at Harvard University and directed towards a white screen erected on the Harvard Observatory, somewhat less than a mile distant.

More recently the production of shadow bands by searchlight has received careful study by Mr. P. R. Bassett,[2] research engineer of the Sperry Gyroscope Company, who, working with a 60-inch searchlight with a beam candle power of 800,000,000, observed at a distance of two miles conspicuous displays of shadow band phenomena exhibiting nearly all the general characteristics, as to motion, spacing and irregularities, which he observed in the case of the total eclipse of last January 24 from a station at Stratford, Connecticut.

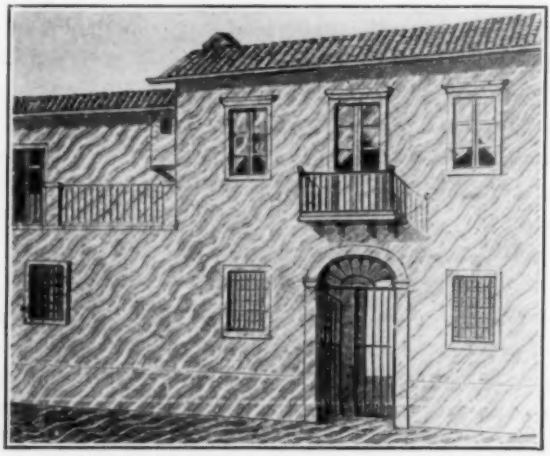
Because of the transient and elusive character of shadow band phenomena, all attempts at photographing them prior to the eclipse of 1925 have been futile. For the eclipse of 1923, Professor Douglass, of the University of Arizona, had devised a special form of camera with which he had succeeded in obtaining satisfactory photographs of artificial shadow bands, and with which he had hoped to catch the first impressions of the true eclipse bands. The limited staff of the party at his station, however, was not sufficient to put into operation the shadow band camera in addition to other apparatus demanding first consideration.

It was at the instigation of Professor Douglass that the photographing of shadow bands was added to the program of our party from Harvard University. We took for our station a location near the Van Vleck Observatory at Middletown, Connecticut, and had for our primary object the measurement of radiation from the solar corona with a vacuum thermocouple, collaborating with the Bureau of Standards for this purpose.

[1] *Harvard Observatory Annals*, 18: 95.

[2] *Popular Astronomy*, 33: 232.

The operation of the special shadow band camera was made possible through the prompt shipment of the outfit by Professor Douglass from Arizona to our station at Middletown, and the courtesy of two additional members of our party, Mr. D. W. Mann, mechanician of the Jefferson Physical Laboratory, and Mr. Kenneth Gell.

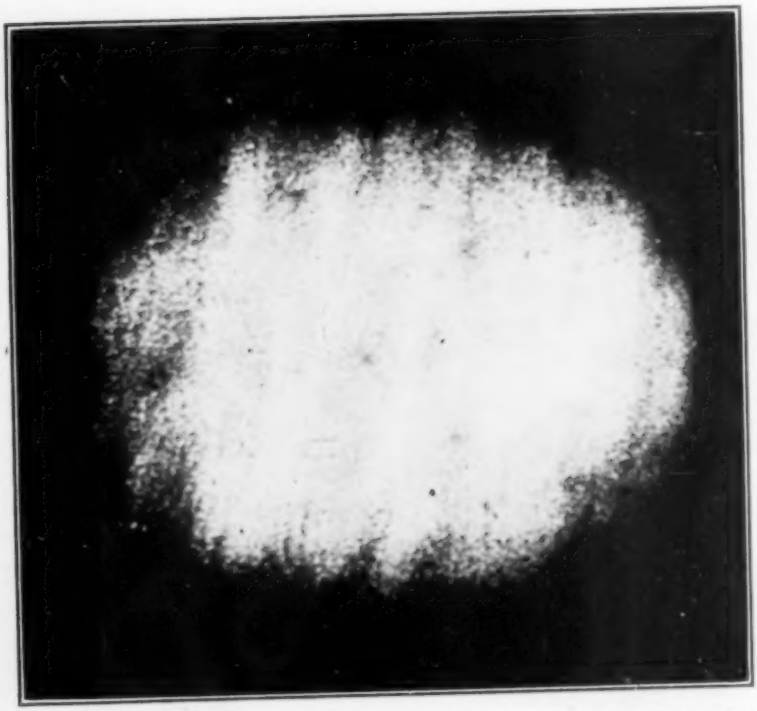


SHADOW BANDS FROM AN OLD DRAWING

The specially designed camera is shown in an accompanying illustration and consisted essentially of a concave mirror of thirteen inches diameter and about four feet focal length. Six inches back of the focus was the film carrier just in front of which passed a focal plane shutter capable of producing extremely short exposures. The camera was kept directed to the sun and was operated by Mr. Mann from about three minutes before to about three minutes after totality. The best exposure came within about five seconds of totality and the blurred, out-of-focus images of the slender solar crescent were seen upon development to be crossed by bands of light and shade due to the atmospheric irregularities through which the narrow shaft of sunlight passed to produce the image recorded. Unquestionably these would have been lost had the exposures been made in the focus of the mirror. The extra focal method of exposure had the effect of accentuating, or one might almost say magnifying the impressions received.

The original image was sufficiently clear to allow a twofold enlargement which is shown in the reproduction. The bands appear sufficiently well defined on the negative to allow for measurements, which, when reduced, give two and a half inches for the distance between adjacent bands at the moment of the exposures, a value not inconsistent with estimates from visual observations.

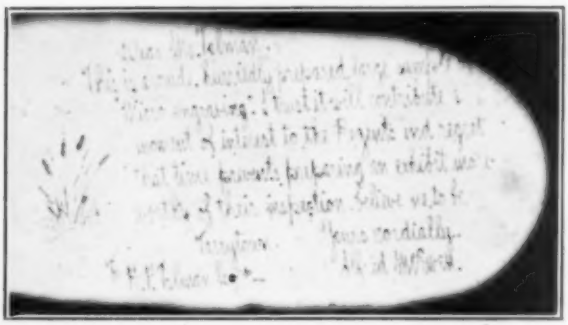
SHADOW BAND APPARATUS AS SET UP AT MIDDLETOWN, CONN., FOR THE ECLIPSE OF JANUARY 24, 1925.



SHADOW BANDS PHOTOGRAPHED AT THE ECLIPSE OF JANUARY 24, 1925, BY MEMBERS OF THE ECLIPSE PARTY FROM HARVARD UNIVERSITY, USING A SPECIAL CAMERA DEVISED BY PROFESSOR DOUGLASS, OF THE UNIVERSITY OF ARIZONA.

The Lord's Prayer
Our Father, who art in heaven, hallowed be Thy name. Thy
kingdom come. Thy will be done on earth, as it is in heaven.
Give us this day our daily bread, and forgive us our
trespasses as we forgive those who trespass against us
and lead us not into temptation, but deliver us from evil.
Amen.
Engraved for Smithsonian Institution,
by Albert Wolfe, N.E., 2 Dec 1928.

THE LORD'S PRAYER SEEN THROUGH THE EYE OF A NEEDLE ENLARGED ABOUT 72,000 TIMES.



MICRO-ENGRAVING

By R. P. TOLMAN
U. S. NATIONAL MUSEUM

SOME months ago the U. S. National Museum received a note of forty-six words engraved on glass, so small that it was necessary to enlarge it eighty-eight times before it could be read easily. This micro-engraved letter, which as shown above is enlarged about 70,000 times, was engraved by Alfred McEwen and was a preliminary to the permanent exhibit which has just been placed on exhibition in the Division of Graphic Arts, Smithsonian building.

The present exhibit consists of The Lord's Prayer, shown inside of the eye of a sewing needle, magnified 145 diameters. About 13,500 complete prayers of fifty-six words each could be engraved in one square inch, but this is very large compared to one measured by the Bureau of Standards, which was so small that 781,250 would have to be cut to cover one square inch; this is equivalent to 43,694,000 words. The extreme smallness of these engravings is almost incomprehensible.

The micro-engraving on exhibition was made February 10, 1925, and is very clear and distinct. It was engraved on glass, with a diamond point, by means of a micro-pantograph. The machine itself is as wonderful as the work it does. The first machine to do work of this character was invented and used by the London banker W. Peters in 1852. Fifty and sixty years ago micro-engravings were quite common, but at present they are very rare.

In time of war microscopic messages could be sent engraved on a shoe nail, on a ring or on a brass button, or an eyeglass, on almost any old thing that is smooth and hard, and they would be next to impossible to locate except by the person who knew where to look.

That it is possible for any machine to be built so accurately, without apparently any lost motion, that it is able to produce work that can only be seen under a high-power microscope and some of it is so fine that it is read only with the greatest difficulty, is almost inconceivable, but still the fact remains that it is true.

DR. ROBERT ANDREWS MILLIKAN

DIRECTOR OF THE NORMAN BRIDGE LABORATORY OF PHYSICS AND CHAIRMAN OF THE ADMINISTRATIVE COUNCIL OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY.

THE PROGRESS OF SCIENCE

"MILLIKAN" RAYS

By WATSON DAVIS, Managing Editor, Science Service

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DISCOVERY of ultra-X-rays a hundred times more penetrating than ordinary X-rays were announced at the Madison meeting of the National Academy of Sciences on November 9 by Dr. R. A. Millikan, director of the Norman Bridge Laboratory of Physics of the California Institute of Technology, Pasadena, California, as the climax of twenty years of search for the cause of a mysterious radiation. Two physicists, Sir Ernest Rutherford and J. C. McClennan, noticed an unaccountable effect on their electroscopes in 1903, and the Germans tried to determine its cause by high balloon ascensions just before the world war.

Dr. Millikan's researches have extended over a decade, during which time he was assisted by I. S. Bowen, Russell Otis and Harvey Cameron.

To account for the ultra-X-rays, it is necessary to conceive that space is filled with rays of one sort or another traveling in all directions with the speed of light. This, Dr. Millikan says, is "a conception which is almost too powerful a stimulus to the imagination."

So far, Dr. Millikan has not proposed a name for the newly described radiations, though some of his colleagues have suggested calling them "Millikan rays" in his honor. He gives them a purely descriptive name, "penetrating rays." Apparently they merit the title, for according to their discoverer they will pass through six feet of solid lead before they are extinguished, whereas the "hardest" X-rays, up to the present the most penetrating radiations known, are stopped completely by half an inch of lead.

The wave-length of the "penetrating rays" is almost unimaginably short, being much less than the wave-lengths of the "hard" X-rays and of gamma rays from radium, the shortest vibrations at present familiar to physicists. The new rays fit on at the top of the known spectrum, and extend it into regions as yet unexplored. At the bottom of the spectrum are the very long waves of low-frequency alternating electric current, and in the zone above them the radio waves, with possible lengths of a mile or more. Then, with rapidly diminishing wave-lengths, come the infra-red heat rays, below the visible spectrum of light, then the light waves themselves, passing out into the ultra-violet radiations above the spectrum. In this region the wave-lengths are short enough to stagger the average person's imagination—ordinary light waves, for example, average around one fifty thousandths of an inch in length. Above the ultra vio'et come the still shorter waves of the X-rays and the gamma rays of radium; and above these, completing the series so far as now known, the new "penetrating rays."

Where the rays come from is an unsolved mystery. They enter the highest atmosphere from the depths of outer space, being born apparently of the disintegration of atoms or of their transmutation into other elements. Dr. Millikan states that if sufficient energy for the transmutation of elements could be generated the process would bring forth penetrating rays as a by-product. But inasmuch as the immense energy of ten

million volts or more would be necessary for this, he does not regard the prospect of human production of penetrating rays to be very promising. The concluding part of Dr. Millikan's paper follows:

HIGH FREQUENCY RAYS OF COSMIC ORIGIN

By Dr. R. A. Millikan

We chose for the first experiment Muir Lake (11,800 feet high), a beautiful body of water hundreds of feet deep just under the brow of Mount Whitney, the highest peak in the United States. Here we worked for the last ten days in August, sinking our electroscopes to various depths down to 60 feet. Our experiments brought to light altogether unambiguously a cosmic radiation of such extraordinary penetrating power that the electroscope reading kept decreasing down to a depth of 45 feet below the surface. The atmosphere above the lake was equivalent in absorbing power to 23 feet of water, so that we had found rays, coming into the earth from outer space, so penetrating that they could pass through 45 plus 23, equalling 68 feet of water or the equivalent of 6 feet of lead, before being completely absorbed. This represents rays much harder (more penetrating) than any which had before even been imagined.

The most penetrating X-rays which we produce in our hospitals can not go through half an inch of lead. Here were rays originating somewhere out in space, at least a hundred times more penetrating than these.

Further, high penetrating power means, according to modern physics, simply high frequency or short wave-length. Our experiments indicate, then, that there is a region of frequencies as far up above the X-ray frequencies as are these latter above the frequencies of light waves.

They show quite definitely, too, that these highest frequency rays are not homogeneous, but have a measurable spectral distribution, the shortest waves which we observed being a little less than twice the frequency of the longest, for the rays which we actually observed in Muir Lake changed hardness or frequency as they were filtered through greater and greater thicknesses of water, just as X-rays are successively hardened by passing through successive layers of lead. The experiments with the sounding balloons indicate that the frequencies of these cosmic rays do not extend over into the X-ray region of frequencies, else we should have obtained larger discharges in the experiments with sounding balloons when nine tenths of the atmosphere had been left beneath us.

Further, we obtained good evidence that these cosmic rays shoot through space in all directions, this evidence being found in the fact that we could observe no change whatever in their intensity throughout day or night.

All the results obtained in Muir Lake were checked with wonderful completeness by another set of observations in another snow-fed lake—Arrowhead Lake—300 miles away from Muir, 7,000 feet lower, and equally deep, where the Arrowhead Lake Development Company kindly put all their facilities at our disposal. Indeed, the absorbing power of the atmosphere between the elevations of Muir and Arrowhead lakes is the equivalent of about two meters of water, and as a matter of fact every reading in Arrowhead was practically identical with one taken in Muir at a depth two meters lower.

We can draw some fairly reliable conclusions as to the origin of these very penetrating and very high frequency rays. The most penetrating rays that we have known anything about thus far, the gamma rays of radium

and thorium, are produced only by nuclear transformations within atoms. This means that they are produced by the change of one atom over into another atom, or by the creation of a new type of atom. It is scarcely possible, then, to avoid the conclusion that these still more penetrating rays which we have here been studying are produced similarly by nuclear transformations of some sort. But these transformations must be enormously more energetic than are those taking place in any radioactive changes which we know anything about. For the frequency of any emitted ray is, according to our present knowledge, proportional to the energy of the subatomic change which gives birth to it. We can scarcely avoid the conclusion, then, that nuclear changes having an energy value perhaps fifty times as great as the energy changes involved in observed radioactive processes are taking place all through space, and that signals of these changes are being sent to us in these high frequency rays.

The energy of the nuclear change which corresponds to the formation of helium out of hydrogen is known, and from it we have computed the corresponding frequency and found it to correspond closely to the highest frequency rays which we have observed this summer. The computed frequencies of these rays also correspond closely to the energy involved in the simple capture of an electron by a positive nucleus. It is possible that this phenomenon is actually going on all through space. This is I think the most probable source of these rays. It is true that the formula underlying this computation of the frequencies of these rays from their absorption coefficients is of uncertain validity. It is a formula, nevertheless, that works well in the frequency range in which we can get independent checks upon it, namely, in that of the X-ray field and the gamma ray field.

According to this formula the wave length of the shortest waves which we have here investigated is .0004 Angstroms, or but one fiftieth of that of the hardest gamma rays heretofore known, and but one ten millionth that of ordinary light. The longest wave length which we have found is about five thirds of the shortest, or .00067 Angstroms.

When these extraordinarily high frequency rays strike the earth, according to the now well-established Compton effect, they should be transformed partially into soft scattered rays of just about the hardness, or the wave length, of the soft rays which we have actually observed on Pike's Peak and Mount Whitney. The reason these soft rays were more plentiful on the mountain peaks than at Pasadena would then be found simply in the fact that there are more than twice as many of the hard rays to be transformed at the altitudes of the peaks than at that of Pasadena. This seems to be the solution of the second of our summer's problems.

But how can nuclear transformation, such, for example, as the formation of helium out of hydrogen or the capture of an electron by a positive nucleus, be going on all through space, the resulting rays coming apparently as much from one direction as from any other, and certainly not a whit more plentifully from the direction of the sun than from that diametrically opposite to it, as evidenced by the entire equality of our midday and midnight observations? The difficulty is not so insuperable, in view of the transparency even of large amounts of matter for these hard rays, combined with Hubble's recent proof at the Mount Wilson Observatory that some of the spiral nebulae are at least a million light years away. The centers at which these nuclear changes are taking place would then only have to occur at extraordinarily widely scattered intervals to produce the intensity of the radiation observed at Muir Lake.

The only alternative hypothesis to that above presented, of high frequency rays traversing space in all directions, might seem to be to assume that the observed rays are generated in the upper layers of the atmosphere by electrons shooting through space in all directions with practically the speed of light. This hypothesis might help in interpreting the mysterious fact of the maintenance of the earth's negative charge, but it meets with insuperable obstacles, I think, in explaining quantitatively the variation with altitude of the ionization in closed vessels. In any case, this hypothesis is, in its most important aspect, very much like the one represented above, for it, too, fills space with rays of one sort or another travelling in all directions with the speed of light. From some such conception as this there now seems to be no escape. And yet it is a conception which is almost too powerful a stimulus to the imagination. Professor MacMillan, of Chicago, will wish to see in it evidence for the condensation into matter out somewhere in space of the light and heat continually being radiated into space by the sun and stars, and the psychists will be explaining all kinds of telepathic phenomena by it.

In any event, our experiments seem to point to the following conclusions: (1) That these extraordinarily penetrating rays exist; (2) that their mass absorption coefficient may be as high as .18 per meter of water; (3) that they are not homogeneous, but are distributed through a spectral region far up above X-ray frequencies—probably 1,000 times the mean frequencies of X-rays; (4) that these hard rays stimulate, upon striking matter, softer rays of about the frequency predicted by the theory of the Compton effect; (5) that these rays come into the earth with equal intensity day and night and at all hours of the day or night, and with practically the same intensity in all directions.

THE WATER-COOLED VACUUM TUBE AND TRANSATLANTIC TELEPHONY

THIS photograph shows Sir Joseph Thomson, the great English physicist, and Dr. F. B. Jewett, vice-president of the American Telephone and Telegraph Company and president of the Bell Telephone Laboratories, Inc., at the time of the former's visit to these laboratories. They are inspecting the 10 k. w. water-cooled vacuum tube developed by the Bell Telephone engineers. These tubes are used in the 150 k. w. radio transmitting station at Rocky Point, Long Island, at which tests undertaken for the purpose of developing commercial transatlantic telephony have been under way for the past four years. At the present time, a somewhat similar transmitting station, employing the same tubes, is under erection in England and when complete will make two-way testing and ultimately two-way telephony possible.

The transatlantic tests thus far completed constitute a very extensive survey of the effect of atmospheric conditions on the transmission of radio signals throughout all times of day and night and all seasons of the year. Before commercial transatlantic telephony is practicable, it will be necessary to supply transmitting apparatus which is so flexible in capacity as to make possible the clear transmission of the voice at all times. Furthermore, the transmitting apparatus must be so designed as to connect to the telephone land lines in both this country and Europe so that a telephone subscriber in Kansas City can converse with one in some remote part of

England as readily as though they were each located at their respective radio stations. The fundamental engineering difficulty encountered lies in the extreme variability of atmospheric conditions, the sending power required to produce a given intensity of received signal frequently increasing by 10,000 within the space of a few hours.

SIR JOSEPH THOMSON AND DR. F. B. JEWETT.

There is an old saying to the effect that success in little things leads to success in big things. The large water-cooled vacuum tube and its tiny ancestor, the telephone switchboard lamp, illustrates a case in point. Several years ago, Mr. W. G. Houskeeper, of the Bell Telephone Research Laboratories, undertook to cheapen the manufacture of switchboard lamps.

DR. HERBERT E. IVES, PRESIDENT OF THE OPTICAL SOCIETY OF AMERICA

DR. IVES TOOK AS THE TOPIC FOR HIS RETIRING PRESIDENTIAL ADDRESS "SOME PHOTOGRAPHIC PROBLEMS ENCOUNTERED IN THE TRANSMISSION OF PICTURES BY ELECTRICITY." THE PORTRAIT HERE REPRODUCED WAS TRANSMITTED OVER A LONG DISTANCE TELEPHONE LINE BY THE METHOD DESCRIBED IN THE ARTICLE BY DR. IVES IN THIS ISSUE.

For one thing, he aimed to eliminate the platinum wire which was used to bring the filament heating current through the glass wall of the lamp. Copper wire possessed one of the requirements necessary to an air-tight seal in that the molten glass adhered closely to the wire, but copper and glass, of course, have quite a different temperature coefficient of expansion, and success came only after Mr. Houskeeper found that by giving the copper wire a peculiar cross-sectional shape no cracking occurred.

His success with the very fine copper leads which he was using for switchboard lamps and the ease of making the copper seals, once the secret was learned, led him to study other and bigger types of seals between glass and copper. Some of these he brought to enormous sizes compared with seals which had previously been made. For example, in one type of vacuum tube which has been developed at the telephone laboratories, the filament heating current is over 90 amperes.

The significance of the water-cooled tube development to the radio art can scarcely be overestimated. It makes available unit tubes so large that only a very few are necessary to operate even the largest radio stations now extant with all the flexibility of action attendant upon the use of tubes.

THE PRINCIPLES OF THE TELEPHONE APPLIED TO THE PHONOGRAPH

THE engineers of the Bell Telephone Laboratories have recently made notable improvements in the phonograph art. They will be reported in an article in the December issue of the *Telephone Review*, which we are permitted to quote.

Far from being a strange place from which improvements in the phonograph might emanate, these laboratories constitute perhaps the most natural source in the world. A casual comparison might lead one to conclude that the phonograph operates mechanically while the telephone is a piece of electrical apparatus; but underlying this very superficial difference is the fact that the telephone is as much mechanical as it is electrical and that both devices are actuated by and reproduce speech sounds and the allied sounds of music. Because of this common characteristic there are similarities between the two instruments which are far more fundamental than might be guessed at first.

Adopting telephone terminology, the ordinary phonograph is a transmission line for mechanical vibrations which behaves, or rather should be made to behave, in a manner analogous to the telephone transmission line for electrical vibrations. The problems which arise in the perfecting of the phonograph transmission circuit are practically identical, from a mathematical point of view, with those met in the telephone circuit. It may be of interest to mention just a few of the analogous features. The elasticity of the phonograph needle point takes the place of a condenser, the pivoted needle arm corresponds to a transformer or repeating coil, the inertia of the needle arm to an inductance, the elasticity of the diaphragm to a condenser and the horn from which the sounds finally issue is the counterpart of a resistance. It is not surprising, therefore, that the telephone engineers should possess an insight into the problems of the phonograph which could hardly have been obtained by any other avenue than the intensive study of the telephone.

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IMPROVEMENT OF THE PHONOGRAPH

MEASURING THE "MECHANICAL IMPEDANCE" OF THE SOUND TRANSMITTING PORTIONS OF A PHONOGRAPH BY A SPECIALLY DESIGNED BRIDGE IN A MANNER ANALOGOUS TO THE BRIDGE MEASUREMENT OF ELECTRICAL IMPEDANCES.

Applying to the mechanical transmission line of the phonograph the practices which have long been standard in the electric transmission line of the telephone has resulted in an instrument which marks a great improvement over the present phonograph in all respects. The sound of the voice and all music is far more natural; the volume of sound can be much increased without unpleasant "blasting" due to resonance; and wear on records is much reduced.

So far as its outward construction is concerned, the new phonograph appears very similar to the old. To the critical eye its interior differs, however, in many fundamental respects, especially in the construction of the diaphragm, the needle arm and the horn. This horn, although several feet in length, is folded back and forth on itself so as to be easily contained in cabinets about the size of the present phonograph cabinets.

Cutting of records has also come in for an improvement corresponding to that in the reproducing instrument. This has been made possible by the perfecting of vacuum tube amplifiers, so that the energy used in driving the cutting tool through the master record is not derived entirely from the sound waves, but is largely supplied by an electromagnetic device connected to the output of the amplifier.

The Western Electric Company has recently consummated contracts through which these improvements in recording, as well as in phonograph instruments, are now to become available to the public.

EVOLUTION, THE COURT AND THE CHURCH

JUDGE JOHN T. RAULSTON, who presided at the Scopes evolution trial at Dayton, Tenn., urged in New York City on November 8 that the state prohibit the teaching of evolution in her schools in order to prevent corruption of society and the downfall of civilization. Speaking before an audience in Calvary Baptist Church, where he was introduced by the pastor, the Rev. John Roach Stratton, he defined this conception of evolution and declared that as judge it had been his duty to combat it in order to "uphold the integrity of the Bible."

According to the report in the *Times*, the judge told first of his own mountain upbringing, which included daily instruction in the Bible. "My father and mother tried to teach us to believe in Jesus Christ," he said, "and we thought that was good enough. We of Tennessee esteem science, we love knowledge. But we know that true science is consistent with Christ and with his religion, because God made both. If science is not consistent with Christ's religion, with all due reverence to science, we will take our choice as to which we will keep."

It was for this reason, he said, that the legislature of Tennessee had a "perfect right" to declare the teaching of evolution against the law. He paid tribute to William Jennings Bryan and to the other lawyers of the prosecution. Then he denounced Clarence Darrow, of the defense, and pictured him as cringing for mercy before the Court, "when I might have sent him to jail for contempt." Bryan's conduct at this juncture, he said, "illustrated the comparison between the Christian and the un-Christian. Bryan," he said, "slipped over to my desk, and, laying his hand on my arm, said, 'Judge, be merciful.'"

"The counsel for the defense," he went on, "brought learned scientists from this City of New York and from many other cities to enlighten the court on what the Tennessee statute meant when it said that it was against the law to teach evolution to our little ones. The meaning of the statute was not ambiguous; it was perfectly clear to the court. That is why I did not admit their evidence.'

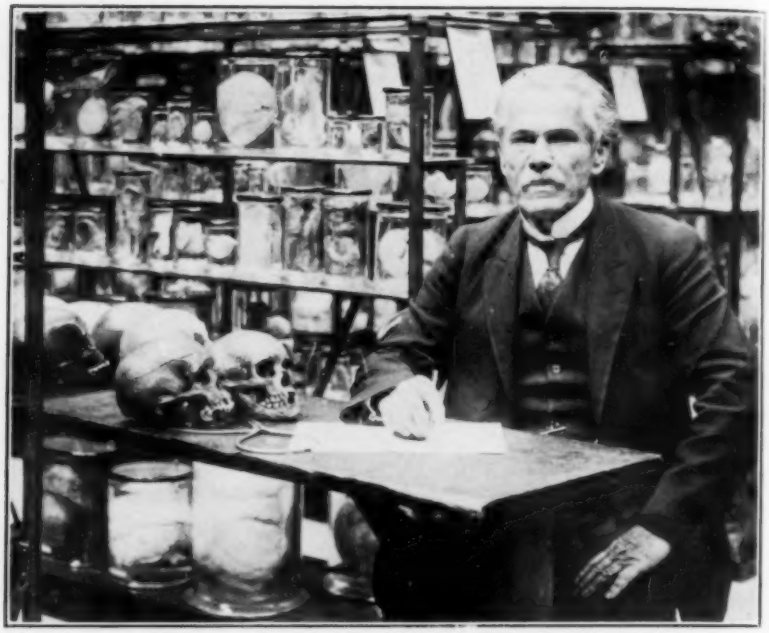
Judge Raulston condemned evolution as "only a theory, a hypothesis, a guess," and quoted Darwin and others to the effect that evolution had "robbed them of their hope of resurrection."

Depicting his idea of the origin of evolution, he said: "A couple of scientists wandered down to the seashore one day and found some old bones and fossils. This proved to them that all life is a result of a little accident that happened millions of years ago in the bottom of the ocean. Some atoms of carbon and hydrogen and oxygen got together down there and suddenly there was a little thing that swam around.

"Pretty soon it got a little bigger and crawled out on shore. It had two freckles on it, and those were eyes, and if it had had a hundred freckles I wonder if you and I would have a hundred eyes. Well, it had two warts on its underneath, and if it had had a hundred warts I wonder if we would all be like centipedes.

"An evolutionist comes to me and says he has a proposition, and I ask him what he can give me. He says he can give me these bones and fossils, but that I must abandon my belief in Genesis, my belief in the immaculate conception and the Virgin birth, my belief in the prophets and in Revelation.

"And I answer him back, 'Take your doctrine that teaches that my ancestors were monkeys and apes, and stick it in that hot place the Scripture tells us of!'"



DR. ALEŠ HRDLIČKA,

CURATOR OF THE DIVISION OF PHYSICAL ANTHROPOLOGY OF THE U. S. NATIONAL MUSEUM. DR. HRDLIČKA HAS JUST RETURNED TO WASHINGTON FROM AN EXPEDITION TO AUSTRALIA, INDIA, CEYLON, JAVA AND SOUTH AFRICA IN THE INTEREST OF RESEARCHES ON MAN'S ANTIQUITY AND EVOLUTION.

Judge Raulston further denounced evolution on the ground that it was an incentive to larceny and murder. "If I listen to evolution and lose my faith in Genesis," he said, "I am afraid I'll lose faith in the rest of the Bible; and if I want to commit larceny I'll say I don't believe in the part of the Bible that says 'Thou shalt not steal.' Then I'll go out and steal." The same thing might happen, he said, if he wanted to commit murder.

Judge Raulston concluded with a second denunciation of those who accuse some Tennesseans of being yokels. "In behalf of my home state," he said, "I want to tell you that the charge that we are yokels and ignoramuses is not justified. No man is justified in calling us that. They have no right to charge my people with being ignoramuses. But I will say that if more learning will cause us to lose our faith in the deity of Christ and our hope in resurrection, then I pray to God to leave us in our state of ignorance."

THE KANSAS CITY MEETING OF THE AMERICAN ASSOCIATION

THE eighty-second meeting of the American Association for the Advancement of Science will be held at Kansas City from December 28, 1925, to January 2, 1926, under the presidency of Dr. Michael I. Pupin, of Columbia University. Annual meetings so far west as this are of infre-

DR. EPHRAIM PORTER FELT,

NEW YORK STATE ENTOMOLOGIST, WHO RECENTLY COMPLETED THIRTY YEARS OF SERVICE. AN ARTICLE BY DR. FELT ON "INSECTS AND HUMAN WELFARE" APPEARS IN THE PRESENT NUMBER OF THE MONTHLY.

quent occurrence and this is the first to be held in Kansas City. This year brings the great scientific convention to a region characterized by typical American progress and prosperity, to a community of high intellectual and educational ideals, and many members and other friends of the association who dwell in the region now to be visited and who do not generally find it possible to attend the annual meetings, will be able this year to receive the benefits of attending. The distance to be traveled will be relatively short from places in the Mississippi and Missouri valleys, and the facilities for transportation to Kansas City from all parts of the country are unsurpassed.

The hotel accommodations at Kansas City are excellent. The larger hotels are conveniently grouped in a small area and the Kansas City Junior College, at which many of the sessions will be held, is situated but a short distance away. The local arrangements for the meeting are in the hands of an ab'e local committee, of which Dr. A. Ross Hill is chairman. The Convention Bureau of the Kansas City Chamber of Commerce, which is deeply appreciative of the aims of men and women of science, is giving very valuable aid to the local committee.

The preliminary announcement of the meeting appears in *Science* for November 27, a complimentary copy of which has been sent to each subscriber for THE SCIENTIFIC MONTHLY. A list of Kansas City hotels was published in *Science* for November 14, and additional announcements are to be made in *Science* from week to week. The general program of the meeting, which will be available at the registration room in Kansas City on the morning of Monday, December 28, will contain full information.

All branches of science will be well represented in the sessions of the association and of the numerous associated societies that will take part in the convention. A series of important general sessions will be devoted to lectures by prominent scientific men on the general aspects of their fields of study and another series of illustrated popular lectures, also by leading scientists, will bring the benefits of the meeting to those who are not engaged in scientific work.

The address of the retiring president of the association, Dr. J. McKeen Cattell, president of The Psychological Corporation and editor of *Science* and THE SCIENTIFIC MONTHLY, will be given on Monday evening, on "Some Psychological Experiments." The annual Sigma Xi lecture, under the joint auspices of the association and the Society of Sigma Xi, will be given on Tuesday evening by President F. D. Farrell, of the Kansas State Agricultural College, on "The Desert becomes a Garden." Dr. Dayton C. Miller, of the Case School of Applied Science, president of the American Physical Society, will give his presidential address on Tuesday afternoon on "Ether Drift Experiments at Mt. Wilson." The annual Josiah Willard Gibbs lecture, under the joint auspices of the association and the American Mathematical Society, will be given on Wednesday afternoon by Professor James Pierpont, of Yale University, on "Some Modern Views of Space." A program of general interest on the rôle of science in education is planned also for Wednesday afternoon. The Wednesday evening program will be devoted to a discussion of the general relations of engineering to the fundamental sciences, at which President Pupin will preside. On Thursday evening Dr. F. R. Moulton, of the University of Chicago, will speak on "The Origin and Evolution of Worlds." Several other speakers for general sessions remain to be announced.

One of the features for which the Kansas City meeting may be specially remembered will be the science exhibition, which is being planned on a much more elaborate scale than has ever been attempted before by the association. Individual scientists and research laboratories and institutions are to exhibit research apparatus, methods and results, manufacturers and distributors of scientific apparatus are to display their recent specialties and publishers of scientific books are to show their newest volumes. The exhibition is to be held in the Alladin Hotel, which has just been completed. Ample and convenient space has been provided. The director of the exhibition is Major H. S. Kimberly, who is to be addressed at the Washington office of the association, in the Smithsonian Institution Building.

BURTON E. LIVINGSTON,
Permanent Secretary

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